SAGINAW BAY ARCHAEOLOGICAL PROJECT PILOT TECHNOLOGY ASSESSMENT

BY:

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MARK W. HOLLEY
KENNETH J. VRANA

WITH A CONTRIBUTION BY:

RUSSELL K. SKOWRONEK, PH.D.

SUBMITTED TO:

COASTAL ZONE MANAGEMENT PROGRAM
MICHIGAN DEPARTMENT OF ENVIRONMENTAL QUALITY
(Contract No. 95D-0.07)

SUBMITTED BY:

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INTRODUCTION

In November, 1995, a contract was finalized between Michigan State University and the Michigan Department of Environmental Quality to assess the technologies potentially available for discovering and recovering information about submerged prehistoric sites located on the bottomlands of Saginaw Bay. Dr. William A. Lovis and Dr. Margaret B. Holman were named principal investigators and responsible parties under terms of this contract.

In addition to the principal investigators, participants included Mr. Mark W. Holley, a graduate student specializing in underwater archaeology at the University of Edinburgh, created two GIS data bases, one from an 1857 map and one from a 1987 map. These data were used to obtain a precise reconstruction of bottomland paleolandscapes. Mr. Kenneth Vrana of the MSU Center for Maritime and Underwater Resource Management provided consultation on the technology component of this project. Dr. Russell K. Skowronek of Santa Clara University supplied background material on underwater archaeology resulting from his earlier participation in this research (Lovis et al. 1994).

This first phase of a multi-phase project was to develop the information needed for planning subsequent field phases of the research. This information included: 1) reconstructing bottomland paleolandscapes with greater precision in order to isolate high potential areas for future field study, 2) reconstructing sedimentation rates and regimes for selected areas of the Saginaw Bay bottomlands to assess the nature of preservation of submerged prehistoric sites and the types of technology appropriate for recovering such sites. Information on paleolandscapes and sedimentation was then used: to develop evaluative criteria for exploring, identifying and managing submerged prehistoric sites in Saginaw Bay, and for assessing technologies available to site reconnaissance and recovery. Finally, manufacturers and vendors were consulted to determine the most appropriate currently available technologies for field tests and applications.

Precedence for Prehistoric Underwater Archaeology by Russell K. Skowronek

Thirty years ago, in the nascent days of the "New Archaeology," it was hypothesized that "submerged sites of former occupation" could potentially be revealed through underwater archaeology (Goggin 1960:351-352). In this earliest pronouncement it was assumed that neither Classical/Historical cities nor prehistoric open ocean-front sites would be found because, in the former case, of the lack of elapsed time and, in the latter, because of wave action, thus limiting site potential to protected lakes and seas. However, Goggin was incorrect. Submerged Classical/Historic era towns and ports have been identified and excavated in the Black, Caribbean and Mediterranean Seas (e.g., Blawatsky 1972:115-122; Flemming 1980:162-177; Frost 1972:95-114; Hamilton 1986:73-77; Marx 1972:139-146, 1980:146-147; Raban 1985:59-65, 1988) while a growing number of open-water prehistoric sites are being discovered and investigated.

As early as 1966, after the discovery of submerged forests and peat deposits, researchers began to realize the archaeological potential of the continental shelf and other open water situations (Emery and Edwards 1966:733-737). Old World submerged prehistoric (Mousterian [100,000-40,000 b.p.] through early Iron Age) sites have been discovered in lakes in Switzerland, Ireland and Scotland (e.g., Bocquet 1979:56-64; Morrison 1980:156-161; Ruoff 1972:123-138, 1980:148-155), as well as, in the Mediterranean Sea and the waters off of Northwest Europe (Flemming 1985:21-23). In both fresh and salt water situations underwater archaeologists have identified and successfully excavated intact, stratified habitation sites that contained stone, metal and ceramic artifacts, in addition to faunal and floral remains. For example, the 8,000 year old Neolithic site of Atlit Yam, located in 30-40 feet of water off the north coast of Israel has yielded not only the foundations of buildings and a variety of artifacts but also human burials, faunal remains, hearths with dateable charcoal and intact seeds (Galili et al. 1988:66-67).

In the New World research on submerged prehistoric sites has lagged behind that of the Old World. This is, in part, due to a lack of trained professional personnel. A larger reason, however, is the public fascination with shipwrecks. As in terrestrial archaeology the vast majority of underwater sites are discovered by the general public. For these sport divers the identification of a shipwreck is easier, more romantic and potentially more exciting (due to the profit motive) than the discovery of a drowned prehistoric site.

For these reasons, as well as the earlier development of the sport diving industry in the faunally and floraly diverse (and sometimes warmer and clearer) waters of Florida and California, there has been only a belated recognition of inundated habitation sites outside of the southeastern and southwestern coasts of the

United States (e.g., Anuskiewicz 1988; Cockrell 1980:144-145; Dunbar 1988; Faught 1988; Serbousek 1988; Shiner 1986:138). The evidence from these areas, however, suggests that the potential exists in other parts of the country for evidence of submerged prehistoric human habitation sites. For example, in three meters of water off southern California 4,000-6,000 year old archaeological deposits have been located in high energy coastal settings (Masters 1985:27-34).

In the Southeast discoveries of inundated sites dating from Paleoindian (ca. 11,000 B.P.) to Woodland (ca. 2000 B.P.) times have been made on the Florida Atlantic and Gulf coasts, as well as inland at such locations as Warm Mineral and Little Salt Springs (Cockrell 1980:138-145, 1986:49-57; Dunbar 1988:177-181; Flemming 1985:24-25). Work at these inland sites and such coastal locales as the Venice Beach (Gulf of Mexico) and Douglas Beach (Atlantic Ocean) sites provides proof that <u>in situ</u> artifacts and ecofacts have survived in varied New World environments (Cockrell 1986:52; Ruppe 1980:33-45). In addition to these reports of archaeological sites it is encouraging to note that paleoclimatologists and palynologists have had success in identifying intact pollen profiles in both fresh and salt water environments (Scott 1986; Wendland 1978).

As this brief survey should indicate there has been a growing awareness of the potential of submerged land surfaces to produce evidence of early human occupation of the continental shelf. Another area with acknowledged potential for these remains (e.g., Mason 1981:132) which is as yet untested, is the Great Lakes. Here, researchers (Larsen 1985; Butterfield 1986) have calculated fluctuations in water levels by examining exposed post-Pleistocene beach ridges and submerged landforms. Their findings indicate that during parts of the Early and Middle Archaic periods (8,000-5,000 B.P.) lake levels in the Michigan and Huron basins dropped and so, opened presently innundated lands for occupation. Although no indications of submerged archaeological sites dating from this period have as yet been found, the recent discovery in Lake Michigan of a "forest," radiocarbon dated to 8,000 B.P. (Diving Times 1990:8), adds further credence to the hypothesis that people might have lived on the current bottomlands. Given the discoveries of submerged prehistoric sites made in other parts of the world, it is reasonable to assume that similar in situ deposits should exist in the Great Lakes. The current pilot project is the first systematic attempt to assess the potential for locating prehistoric submerged sites in the Great Lakes (Halsey 1990:10-11). Thus, the model developed here can serve as a basis for future surveys and more refined management of the State's bottomlands.

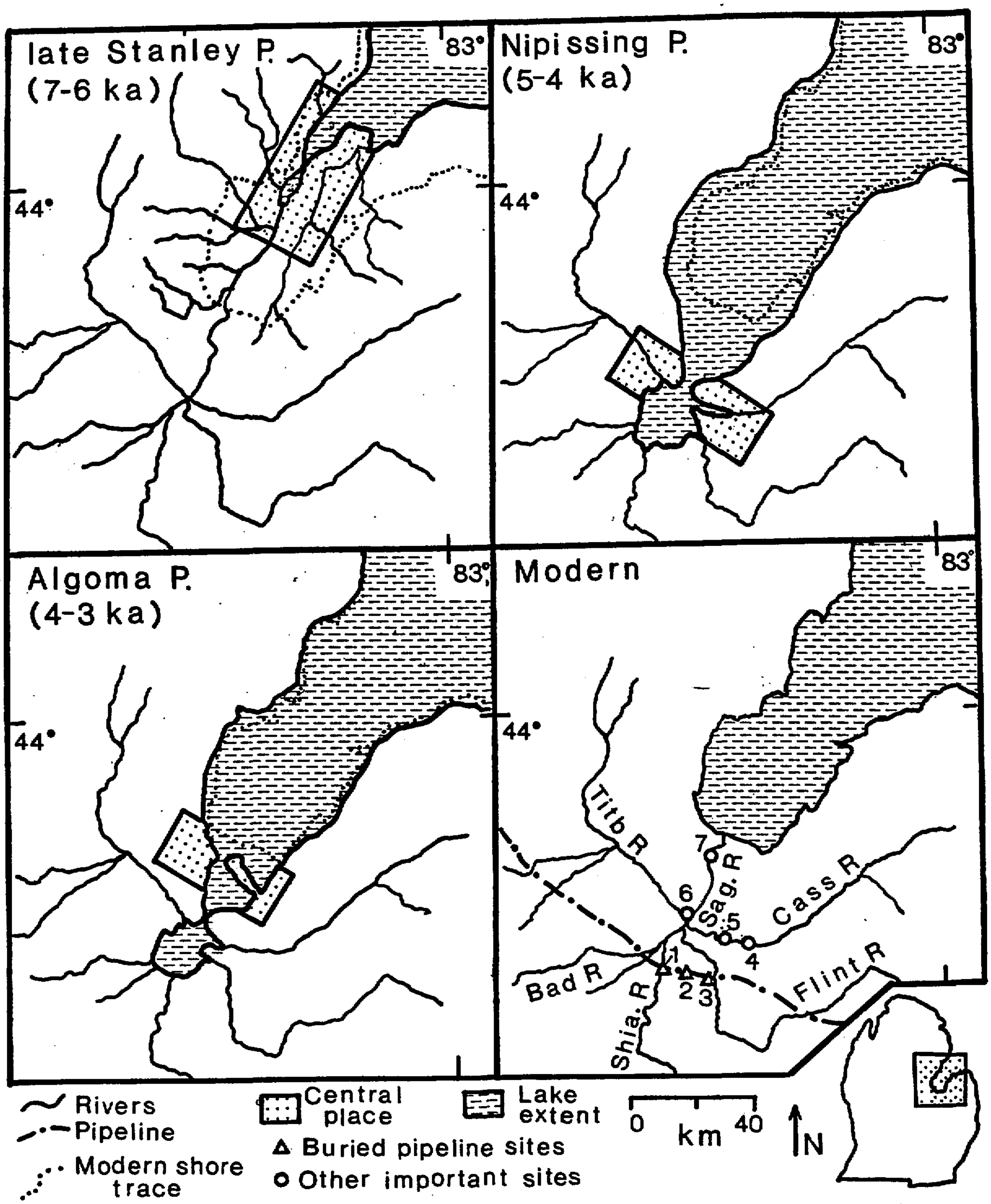
Post Glacial Lake Level History

The retreat of the Saginaw Lobe across the Saginaw Bay region was marked by sequences of water-lain moraines and associated proglacial lakes, the last of which was initiated by the advance of the ice front to the Port Huron Moraine (Bretz 1951; Farrand and Eschman 1974; Leverett and Taylor 1915). As the Late Wisconsinan ice front retreated northward and eastward from the Port Huron Moraine, it exposed successively lower outlets for the water ponded in front of the ice (Farrand and Eschman 1974; Hough 1958; Leverett and Taylor 1915). Levels and outlets of these lakes are summarized in Table 1 and Figure 1 (from Monaghan 1986). The beach ridges associated with certain of these proglacial lakes are often prominent on the margins of Saginaw Bay, as well as along some of the streams which empty into the Bay. The Nipissing Stage terrace is perhaps the most prominent of these. It maintains a northwest-southeast trend through the city of Saginaw. The Algoma Stage ridge is also prevalent, trending northwest-southeast through Bay City (Monaghan 1986).

Sediment deposition across the Saginaw region was largely controlled by levels of Late Wisconsinan and early Holocene proglacial lakes within the Saginaw and Huron basins. Following the retreat of the Saginaw Lobe from the Bay City/Port Huron Moraine into the Lake Huron basin, a series of successively lower lake stages occupied the Saginaw basin (Warren, Elkton, and Algonquin; see Table 1). Although beach ridges associated with the latter two of these stages occur in the Saginaw Bay region, they are generally associated with uplands and are absent in lower elevation coastal contexts (Monaghan 1986).

Continued northward retreat of the ice front to the North Bay area of Ontario, Canada at about 11,000 B.P. (9050 B.C.), exposed the lowest Holocene outlet for the Great Lakes (Fullerton 1980; Karrow 1980; Lewis 1969, 1970;) and initiated the 48 m (158 ft) Stanley Stage (Hough 1958). This low-water stage lasted until about 5500 B.P. (3550 B.C.) (Table 3) when isostatic rebound in the outlet area at North Bay had raised the lake level sufficiently to reinitiate drainage through the St. Clair River outlet at Port Huron (Karrow 1980; Lewis 1969, 1970). The cessation of

Figure 1 - Map of Saginaw Bay Study Area with selected lake stages and submerged drainage systems (from Lovis et al 1994)


late Stanley P.
(7-6 ka)
Nipissing P.
(5-4 ka)
Algoma P.
(4-3 ka)
Modern
83°
44°
Titt. R
Sag. R
Cass R
Bad R
Shia. R
Flint R
1
2
3
4
5
6
7
Rivers
Pipeline
Modern shore trace
Central place
Lake extent
Buried pipeline sites
Other important sites
0
km
40
N

drainage through the North Bay outlet and the reoccupation of the St. Clair outlet initiated the "two-outlet" Nipissing Stage (Lewis 1969). Although Lewis (1969) has suggested that Nipissing Stage water level had reached a maximum transgression of at least 184 m (605 ft) by about 5500 B.P. (3550 B.C.), recent compilations of radiocarbon dates from archaeological sites in the Saginaw Bay region (Monaghan et al. 1986) indicate that the lake level could not have reached an altitude of greater than 181 m (595 ft) before about 4700 B.P. (2750 B.C.) (Table 3). If correct, this suggests that the Nipissing Stage maximum transgression was of much shorter duration than previously believed. Beach ridges associated with the Nipissing Stage occur near the city of Saginaw but are absent within eight to ten miles of Bay City.

The Nipissing stage water level was maintained at between 183 and 184 m (600 to 605 ft) until at least 3700 B.P. (1750 B.C.) (Karrow 1980; Lewis 1969, 1970; Monaghan et al. 1986) when further downcutting of the St. Clair River outlet lowered the lake to the 181 m (595 ft) Algoma stage. Except for the time represented by the Lake Stanley low water stage, large parts of the Saginaw basin were under water until attainment of Algoma Stage water level. During the Algoma Stage, a prominent, generally northwest trending beach ridge was built within the Bay City area. That the Saginaw River was active during the Algoma Stage is suggested by an abandoned, northward trending distributary channel (presently occupied by Salzburg Drain) just west of the present course of the river in Bay City. This abandoned channel is graded to and cuts through the Algoma beach ridge but cannot be traced beyond the ridge.

Previous summaries of lake level history within the Huron basin (Lewis 1969) have suggested that the Algoma Stage water level was maintained until about 2500 B.P. (550 B.C.). Radiocarbon dates from archaeological sites excavated at the Liberty Bridge in Bay City, as well as those from nearby sites within the Saginaw Bay Region, however, indicate that Algoma stage levels began to fall by about 3000 B.P. (1050 B.C.), and the modern Lake Huron water level of 177 m (580 ft) was reached by about 2500 B.P. (550 B.C.) (Speth 1972).

Of critical concern to this research in Saginaw Bay is the time period associated with the Chippewa-Stanley low water stage between 11,000 and 5,000 B.P., recently addressed in detail by Butterfield (1986). Due to the lowered lake levels of this period archaeological sites from the Early Archaic and early Middle Archaic periods are poorly represented, and are presumed to lie under the waters of Lake Huron at various depths. Butterfield argues convincingly that during both recessional and transgressive events the area between the Charity Islands and Bay City would have been a large shallow water impoundment which he terms the 3rd Embayment. Specifically, this embayment would have been present at elevations between 560 and 570 feet (173 and 170 m.), within 20 feet of current lake elevations (Figure 1). The outlet of the Saginaw River system during this period would have been between Point Lookout and the Charity Islands. This location, due to its position near the outlet of a major river system into the Huron Basin, and the proximity of chert resources on the nearby Charity Islands, should have been an optimal location for prehistoric settlement.

TABLE 1
LATE WISCONSINAN AND HOLOCENE LAKE LEVELS
IN THE HURON BASIN*

STAGE	ELEVATION	AGE	OUTLET
Algoma	181 m (595 ft)	3700-2500 B.P. [1] (1750-550 B.C.) 3700-3000 B.P. [2] (1750-1050 B.C.)	St. Clair River
Nipissing			
Saginaw Bay ("Classic")	183-184 m (600-605 ft)	4700-3700 B.P. [3] (2750-1750 B.C.)	St. Clair River, and Chicago River
North Bay (Two-outlet Phase)	183 m (600 ft)	4700-3700 B.P. [1] (2750-1750 B.C.)	St. Clair River, and Chicago River
(Three-outlet Phase)	184 m (605 ft)	5500-4700 B.P. [1] (3550-2750 B.C.)	North Bay Channel, St. Clair River and Chicago River
Stanley [5]	48 m (158 ft)	11,000-5500 B.P. [4] (9050-3550 B.C.)	North Bay Channel
Algonquin	184 m (605 ft)	12,300-11,000 B.P.[4] (10,350-9050 B.C.)	St. Clair River, and Chicago River
Elkton	189 m (620 ft)	12,500-12,300 B.P.[4] (10,550-10,350 B.C.)	St. Clair River, and Chicago River
Warren III	206-202 m (675-665 ft)	12,700-12,500 B.P.[4] (10,750-10,550 B.C.)	Glacial Grand River

NOTES:
1 From Lewis (1970)
2 This report
3 From Monaghan et al. (1986)
4 From Fullerton (1980)
5 Includes all post-Algonquin low-water stages

* Table 1 from Monaghan 1986

RESEARCH PROBLEMS AND DESIGN

Alternative Hypotheses

There is a gap in the archaeological record of Michigan between about 9000 and 5000 B.P. with only a few known sites and isolated artifact finds from the Late Paleoindian (ca. 10,000 B.P.), Early Archaic (10,000-8,000 B.P.), and Middle Archaic (8,000-6,000 B.P.) periods. This hiatus in prehistoric remains coincides with a significant drop in lake levels that occurred when the postglacial Great Lakes drained through a low outlet in Ontario. At the maximum low water stage, Lake Huron was about 350′ (158 m) below its present level. The entire process of retrogression and subsequent transgression took place at varying rates over about 5,000 years (Butterfield 1986). Thus, there was a considerable amount of land available for human occupation that is now underwater.

Explanations for either the relative absence of, or absence of evidence for, humans in Michigan between about 10,000 and 6000 B.P., in comparison to the preceding Paleoindian period and the subsequent Late Archaic, often take lowered lake levels into account along with other relevant environmental variables. In particular, James E. Fitting (1975:57) observes that during the late Paleoindian/Early Archaic periods, the environment was changing from a productive low latitude tundra/spruce parkland to a less productive boreal forest. He suggests that people would have found a greater variety of foods and a more abundant supply along the lake shores, so that most of their "sites are far out from the present-day shores and under many feet of water" (Fitting 1975:57). In support of his hypothesis that late

Paleoindians were adapted to a forested lakeshore environment, Fitting (1975:57) notes that late Paleoindian sites to the north are scattered through forests that were not inundated because isostatic rebound maintained their elevation above current water levels.

It is Fitting's (1975:65) view that Early and Middle Archaic peoples were adapted to deciduous forest and riverine settings. After the glaciers retreated, these environments became established earlier in regions to the south of Michigan. Because many areas of Michigan were forested first with boreal species and later with pine, Early and Middle Archaic peoples would have been in Michigan only on an occasional basis. Thus, the area that is now Michigan saw a real drop in population with people returning in the Late Archaic when modern environmental conditions were reached. If Fitting is correct, there is no reason to expect that Early or Middle Archaic sites are currently under water.

Recent research however, leads us to believe that Early/Middle Archaic people were not only residents of Michigan, but that evidence of their presence exists in Saginaw Bay, and that their archaeological record can be recovered (e.g., Arnold 1977; Peebles and Krakker 1977). Archaeological studies coupled with current environmental reconstructions based on lake level variations (Larsen 1985; Butterfield 1986), pollen profiles (Holman et al. 1986; Kapp et al. 1990), and faunal evidence (Holman 1990; Smith and Egan 1990) during the period of low water, suggest that parts of Michigan may not have been so barren as Fitting (1975) and others (e.g. Mason 1981:126-139) believed (Lovis n.d.). For example, not all Paleoindian and

Early Archaic sites are confined to lakeshores and the exposed land of the Saginaw basin was probably not a uniform pine forest during early portions of the Archaic.

The Environment

Pine was the dominant forest type in the Saginaw area during the retrogression from the main Lake Algonquin water levels of ca. 184 m (605 ft) to the Lake Stanley low water level of 48 m (158 ft), i.e., from sometime about 11,000 B.P. to 9000 B.P. (Butterfield 1986; Kapp et al. 1990:19). Even then however, vegetation was not uniform. Hardwoods such as birch, ironwood/blue beech and elm became established during the pine period. At 10,000 B.P., the upland forests of southern Michigan were quite diverse with oak and aspen in addition to the pine and other hardwoods (Shott and Welch 1984:25,26).

The pine period ended in southern Michigan by 9000 B.P. and in central Michigan by 8000 B.P. when the long warm period known as the hypsithermal began. At the same time, American beech and then hemlock appeared in central Michigan followed by an increase in oak, elm and ironwood. Mixed hardwood forests were established by the time the hypsithermal reached its climax about 6500 B.P. during the transgression to Lake Nipissing levels of 183-184 m (600-605 ft) (Butterfield 1986; Holman et al. 1986). Temperate deciduous forest cover was present at the Harper locality in Shiawassee County at 5840 +/- 100 B.P. (Beta-11881) (Holman et al. 1986:438) and people were exploiting acorns and walnuts at the Weber I site (20SA581) in Saginaw County about 6200-4500 B.P. (Smith and Egan 1990). A variety of berries were also available near the site. Animal bone from the Harper locality (Holman 1990) and the Weber 1 site (Smith and Egan 1990) shows that these forests were inhabited by elk and deer, and by smaller mammals such as beaver, muskrat and raccoon. Aquatic animals including goose, turtles and fish were also present.

The warming trend culminating in the hypsithermal resulted in deciduous forests (and probably open grasslands) in upland settings during the Middle Archaic period. During the rise in lake levels these forests supported game animals. Certainly wetlands were present as well. As Butterfield (1986:126) notes, during the 5000 year period of drastic changes in lake levels, there was always an embayment marked by a constriction or narrows emptying into the main Huron basin. Surely there were also always marshes and wetlands associated with these embayments. During the Hypsithermal these habitats would have provided substantial opportunities for intensive seasonal hunting, trapping, fishing and collecting.

The Archaeological Record

The archaeological record to the landward of Saginaw Bay, i.e. the Saginaw Valley, the western side of the "Thumb", and the northwest side of the Bay has great potential for allowing the design of a high probability strategy for surveying the bottomlands of Saginaw Bay. Not only does the Saginaw Valley have the largest number of reported sites, but recent studies of the Valley and its margins have added new dimensions to our understanding of late Middle Archaic and Late Archaic adaptations. Since Fitting's (1975) The Archaeology of Michigan was written, there have been studies of mobility patterns during various seasons of the year (Robertson

1987), reconstructions of environment and subsistence at Archaic sites (Keene 1981; Smith and Egan 1990), examinations of the role of wetlands in prehistoric subsistence (Lovis 1989, 1990b, and Lovis et al. 1989), plus realizations that prehistoric inhabitants of the Valley buffered cyclical and periodic variability in highly productive lacustrine and wetland resources by also exploiting more stable Valley margins and uplands (Lovis 1986). This new information provides an understanding of Archaic site location that enhances our ability to predict where sites will be found. Thus, we not only believe that prehistoric sites are present in Saginaw Bay, but using our knowledge of the principles of site location derived from the late Middle Archaic and Late Archaic, we have the ability to locate them.

Given that the 3rd embayment (Butterfield 1986) during the Stanley low water stage was environmentally analogous to later high water stage environments, we can make assumptions about life in the unknown Middle Archaic period on the basis of our knowledge of the Late Archaic. We know that during the Late Archaic there was an abundant supply of a variety of foods in the Saginaw Valley (Keene 1981; Lovis 1986). Because of the Valley's position in the transition zone between the Canadian and Carolinian Biotic Provinces, there were northern and southern species of plants and animals present (Robertson 1987:29,30). Further, the configuration of the Valley with a shallow embayment and wetlands surrounded by the higher Valley margins and uplands made available a variety of food and other resources found in these varying habitats. This abundance however, was not uniform over the landscape nor was it necessarily predictable (Lovis 1986:101). Late Archaic peoples of the Saginaw

Valley lived in a diverse and productive environment, but the plants and animals that supplied their food were not always concentrated in one place (Lovis et al 1989). Further, the Saginaw Valley itself, which was environmentally the richest area, was subject to long and short term oscillations in water levels that made this abundance of resources unstable. Late Archaic peoples made use of their highly productive environment by exploiting the variety of forest and wetland resources in the Saginaw Valley, but they also insured against failure of these food supplies by regularly moving to the less productive margins of the valley where the same resources were present in patchier, less homogenous spatial configurations and in lower quantities (Lovis 1986:111).

Seasonal movements to various portions of the valley, its margins, and the adjacent uplands were structured so that people could obtain information about where food was likely to be found, so that they could schedule regularly performed tasks, and so that they could prepare for the next season (Robertson 1987:207-209). Late Archaic peoples, like Historic period peoples, used the transportation network of the Saginaw Valley river system to accomplish these goals. As a result, Saginaw Valley Late Archaic sites are not only located along rivers and streams, but they are more abundant in those locales where the "avenues" of transportation converge, i.e., in the Valley center during the Nipissing stage and at Bay City during the Algoma stage (ca. 3200 to 2500 B.P.). Sites are larger and more abundant in these locations for both logistic and social reasons; people had to pass there to reach other parts of the Valley and these were places to meet with other people to obtain information before proceeding to another destination.

It is likely that Middle Archaic peoples developed an adaptation that was similar to that of the Late Archaic. Wetland and upland resources were present in their environment that were similarly situated with respect to one another. Further, water levels were subject to similar periodicity. The Middle Archaic occupation zone at the Weber I site (Lovis 1990a) shows that like their Late Archaic successors, Middle Archaic peoples used forest resources such as nuts, elk and deer in the fall. This short-term occupation with its local chert does not reflect use by a group of immigrants from the south. Rather, these people were residents of the Saginaw Valley with an established seasonal round. Isolated Middle Archaic projectile point finds do not represent occasional trips to Michigan by southern hunters. They represent the upland portion of a seasonal round which included residence around an embayment during parts of the year.

Given a similar settlement system under similar environmental conditions, the missing portions of the Middle Archaic seasonal round are under the waters of Saginaw Bay. It is likely that a "central place" comparable to the Schultz site (20OSA2) at Green Point, and the Kantzler (20BY30) and 20BY79 sites at Bay City, where people passed on their travels exists at the submerged narrows of the Saginaw River between the Charity Islands and Point Lookout. Other submerged nodes in the transportation system may exist at former stream confluences. Sites around formerly exploited wetlands may be present as well.

Finally, while it is most likely that Middle Archaic sites from the period of the

3rd embayment will be found, Early Archaic sites may also be located. Though we cannot examine the deeply submerged Lake Stanley coastline and associated early embayments which may have been the focus of the Early Archaic settlement system, we may find some segment of the Early Archaic seasonal round. This is especially true where the Saginaw River passed between the Charity Islands and Point Lookout as this area was a source of chert at the narrows of a major stream.

RESEARCH METHODS

Site Data

The Office of the State Archaeologist at the Michigan Historical Center in Lansing records all reported site locations in Michigan on USGS range maps (1:24000). We first obtained site numbers from these maps of all sites between the current shore of Saginaw Bay and 605 ft amsl in Huron, Arenac and Tuscola counties. The 605 ft elevation was chosen because it would have been the shore of both post-glacial Lake Algonquin (ca. 10,500 B.P.) and Lake Nipissing (ca. 5000 B.P.). This elevation of 605 ft. represents the highest water levels in the Huron Basin during the period of human occupation of the region. Sites below this 605 ft limit may be on landforms that continue into the present Saginaw Bay, or may be in settings analogous to those used for sites during low water stages.

Copies of the state site files at the Consortium for Archaeological Research at MSU were then used to obtain information about each site in the list derived from the Michigan Historical Center quad sheets. This information included the age of the site, whether a site was a findspot, lithic scatter, or camp, documentation about the site, and any other recorded relevant observations.

Data about the 192 sites in the list were evaluated to see which sites would be most useful for achieving the research goals of the Saginaw Bay Archaeological Project. First, it was decided to concentrate on sites around outer Saginaw Bay, i.e., those locations between Sand Point and Little Oak Point on the southeast side of the Bay, those locales between Point Au Gres and Point Lookout on the northwest side of the Bay, and those on the Charity Islands. Outer Saginaw Bay was considered to be the most appropriate for our purposes because there is good site location data there as well as the kinds of submerged landforms that have a high potential for prehistoric human occupation, i.e., submerged strandlines and stream confluences. Additionally, sedimentation rates are lower in the outer portions of Saginaw Bay and the water clarity is greater in comparison to inner Saginaw Bay.

Historic sites around the outer Bay were eliminated from further consideration but the locations of most prehistoric sites in this area were plotted on the Caseville, Rush Lake, Au Gres and Point Lookout quadrangles. Some burial mounds, poorly documented sites, or stream-oriented sites were not plotted. The latitude and longitude of each of the resulting 25 prehistoric sites, including those on the Charity Islands, were then entered into the database.

<u>Site Evaluation</u>

Evaluation of plotted site locations around outer Saginaw Bay takes three factors into account; spatial continuity, temporal continuity and settlement system continuity. First, we are interested in sites on landforms that continue out into the current bay because it is likely that sites dating to low water stages will be found on submerged portions of the same landform. Experience in various parts of the Great Lakes shows that sites of different time periods may be found at different elevations of a landform. Late Archaic sites, for example, may be at high elevations that were exposed during this period of occupation. Later Woodland sites on the same landform may be on low elevations which were exposed when water levels dropped from Nipissing or Algoma highs to current levels after the Late Archaic. In Saginaw Bay there are submerged portions of Point Lookout, Point Au Gres, Oak Point and Sand Point and each of these points is the location of at least one prehistoric site. Additionally, there are submerged areas around the Charity Islands which like the current islands may have prehistoric sites.

Temporal continuity at plotted sites around Saginaw Bay is relevant here because if one site was occupied through long periods of time, it clearly was a desirable location for many generations of people. If we can ascertain why a location was attractive throughout prehistory, perhaps we can find similar settings submerged in Saginaw Bay. We know the general age of only 10 of the 25 plotted prehistoric sites and this age is often based on the occurrence of one or two diagnostic artifacts. Many sites yielded only undatable lithic debris when they were surveyed. Since stone tools were made and used throughout the prehistoric period, there is no way to know with precision when a particular site with only lithic waste material (debitage) was occupied. Similarly, a site with one or two artifacts indicative of only one time period may have been occupied in other periods as well, but in the absence of abundant diagnostic material this is not known. Clearly, our temporal control with regard to sites around Saginaw Bay is quite limited. There are only two sites known to be multicomponent. The Botwright site, 20HU20, has Middle Archaic, Late Archaic, Early Woodland, Late Woodland and Mississippian materials. 20HU20, with its Middle Archaic component, is the only site we know of that may have been used during the low water stages of Lake Huron and Saginaw Bay. Depending upon exactly when during the Middle Archaic it was occupied, the waters could have been rising toward Nipissing levels at the time of the Middle Archaic occupation rather than having stabilized at that elevation. The other multicomponent site, 20AC45, was occupied during both the Late Archaic and the Late Woodland Periods. Single component sites include two Late Archaic locales (20HU149, 20AC120), one Middle Woodland site (20AC18), two Late Woodland sites (20HU164, 20AC2), and three unassigned Woodland locales (20HU129, 20HU134, 20HU135).

Finally, we are postulating an Early/Middle Archaic settlement system that was spatially analogous to the Late Archaic settlement system in the same region. The Late Archaic system included seasonal movement through a radial network of rivers and streams, and nodes where people had to pass as they moved through the network (Robertson 1977). Additionally, people placed an emphasis on procuring various forest and wetland resources (Lovis 1986) Thus, we want to find locations, such as stream confluences on the bottomlands of Saginaw Bay that would have been nodes in a mobility network, and we are interested in finding locations in Saginaw

Bay that were in proximity to wetlands during low water stages. The Charity Island sites surely represent central nodes because people moving through the region would have passed nearby and because they are a source for chert with which to make stone tools.

BATHYMETRIC RECONSTRUCTION OF SAGINAW BAY

Introduction

The primary objective of this study was to produce a data set which could be used to reconstruct the bathymetry of the mouth of Saginaw Bay. This data needed to be compatible with both CAD and GIS software so that detailed bathymetric charts could be produced and analyzed. The purpose of these charts was to identify the submerged landscapes of Saginaw Bay and determine how they have changed over the course of the last 100 years in order to locate Archaic age archaeological sites.

Background Research

An extensive search of Federal, State and local records revealed that only two bathymetric surveys of Saginaw Bay have been produced in the last one hundred fifty years. The first of these surveys was commissioned by the Bureau of Topographical Engineers of the War Department of the United States in 1856. This survey was carried out under the direction of Captain J.N. Macomb and Captain G.G. Meade between 1856 and 1858. A series of maps based on this data were produced and published in 1860. The map which concerns the present study is entitled Saginaw Bay and Part of Lake Huron and is currently held in the rare maps collection in the

State of Michigan Library. This map portrays spot depths at an average density of one reading every half mile. In shallower regions of the bay depths are recorded in feet, while areas over 20 feet in depth are recorded in fathoms. The scale of the map is 1:120,000.

The second bathymetric survey of Saginaw Bay was carried out in 1987 under the direction of Mr. Frank Horvath of the State of Michigan Department of Natural Resources. Although the numerical data of this survey is not available, a map based on the data was provided by Mr. Gary Taylor, also of the DNR. This map, entitled Saginaw Bay Bathymetry, portrays the bathymetric contours of Saginaw Bay at a resolution of 1 contour for every 1 foot of change in water depth.

Method

For the purposes of this study both the 1860 and the 1987 map needed to be digitized. This was accomplished by drawing a grid over each map and then assigning an x, y coordinate position to each of the relevant points on the map. The grid used measured 31 cm east/west and 20 cm north/south and was divided into 1 cm subunits. This grid size was chosen because it adequately covered the study area. The 1860 and 1987 maps were both roughly the same scale so the same sized grid was used for each.

The 1860 map needed to have contours produced from the spot depths represented on it. A standard contouring method was used to accomplish this. All units reported on the map were first converted into their equivalents in feet. Contours were then plotted in ;intervals of 5 feet of depth, starting from the shore.

Points of the contours were determined by their numerical ratio to the distance between spot depths. For example, suppose there are two spot depths, one of 30 feet and one of 40 feet. A 35 foot contour would be generated half way between them. A 37 feet contour would be generated 7/10 of the distance between them, and so on. All of the contours of the 1860 map were generated in this fashion.

The digitization of each map was a relatively straightforward process. contours for each 5 feet of depth, starting at the shore and ending at 50 feet were identified. Each contour was then individually digitized. This involved assigning an x, y coordinate value for between 300 and 500 points on each contour. The density of points was chosen in response to the nature of the contour; on sharp curves the point density was 1 point/mm, on straight lines point density was 1 point/cm. This point density allowed both maps to be accurately reproduced.

The x, y point data for each contour was recorded in small macro files which can be accessed by an standard word processing software. This format should allow the data to be ;used in a wide variety of CAD and GIS software.

The CAD software chosen to generate the charts for the present study is called AutoSketch(R) for Windows(TM), Release 1.0, and is produced by Autodesk, Inc. This software was chosen because it is easy to use, compatible with other CAD formats, and has features which allow for the generation and reproduction of precise maps.

<u>Results</u>

Two maps were produced for the purposes of this study. The first is a nearly identical replica of the 1987 bathymetry. The second map is a somewhat more subjective representation of the 1860 bathymetry. The limits of precision of these two maps are discussed below.

The 1987 bathymetry produced by this study is deemed to be an accurate reproduction of the map provided by Mr. Taylor. However, the accuracy of the original map and the density of the point data used to produce it is unknown. It has been assumed, for purposes of this study, that this map is an accurate representation of both the spatial and the bathymetric data peculiar to Saginaw Bay in 1987.

The 1860 bathymetry map of Saginaw Bay has several inaccuracies which warrant caution in its use. The entirety of the longitude measurement are represented between 02′ and 02.5′ too far to the east. The range in this error produces an effect which may either compress or expand individual longitudes. This makes if difficult to directly compare the 1860 bathymetry to the 1987 bathymetry because longitudinal positions can be off by up to 0.5 mile even when the correct longitudes are placed on the map. Another problem which would be encountered if the 1860 map were stretched to fit the 1987 map is that there are no points of reference common to both maps. Reference points such as shorelines, or Big Charity Island cannot be used because theoretically they should have changed position slightly due to shoreline erosion and/or coastal buildup. With no fixed points of reference the true position of any point can only be guessed at, increasing the error factor to well over a mile for most points out in the bay.

A third factor which limits the accuracy of the 1860 bathymetry is the scale of spot depths displayed on the map. Spot depth densities range between one and four readings per square mile. Any bathymetry produced from such a sparse density of readings can only represent a broad overview of the bay. Small scale comparisons are impossible to make as areas up to under 0.5 mile square are not adequately represented. This means that the bathymetric contours plotted on this map may be off by up to on mile in true position. With such a large possible error the map should be viewed with caution.

Summary

The main goals of this phase of the study have been accomplished. Two maps have been produced which depict both the historical bathymetrics of Saginaw Bay and the locations of known archaeological sites (Figures 2 and 3). Both maps are now in digital form, which allows them to be used by a variety of GIS and CAD software packages. Additional archaeological sites and smaller scale bathymetrics may be added to both maps with relatively little effort. Each map should contribute significantly to the identification of submerged, Archaic age archeological sites in Saginaw Bay.

CONCLUSIONS

The preceding components of this report have focused on three primary evaluative criteria;

1) an assessment of evident bottomland features present on the 1857 and 1987 bathymetric maps of Saginaw Bay as they may relate to prior lake levels at

Figure 2 - Digitized 1857 Bathymetric Map of Outer Saginaw Bay Study Area displaying known archaeological site locations

Saginaw Bay Bathymetry - 1857

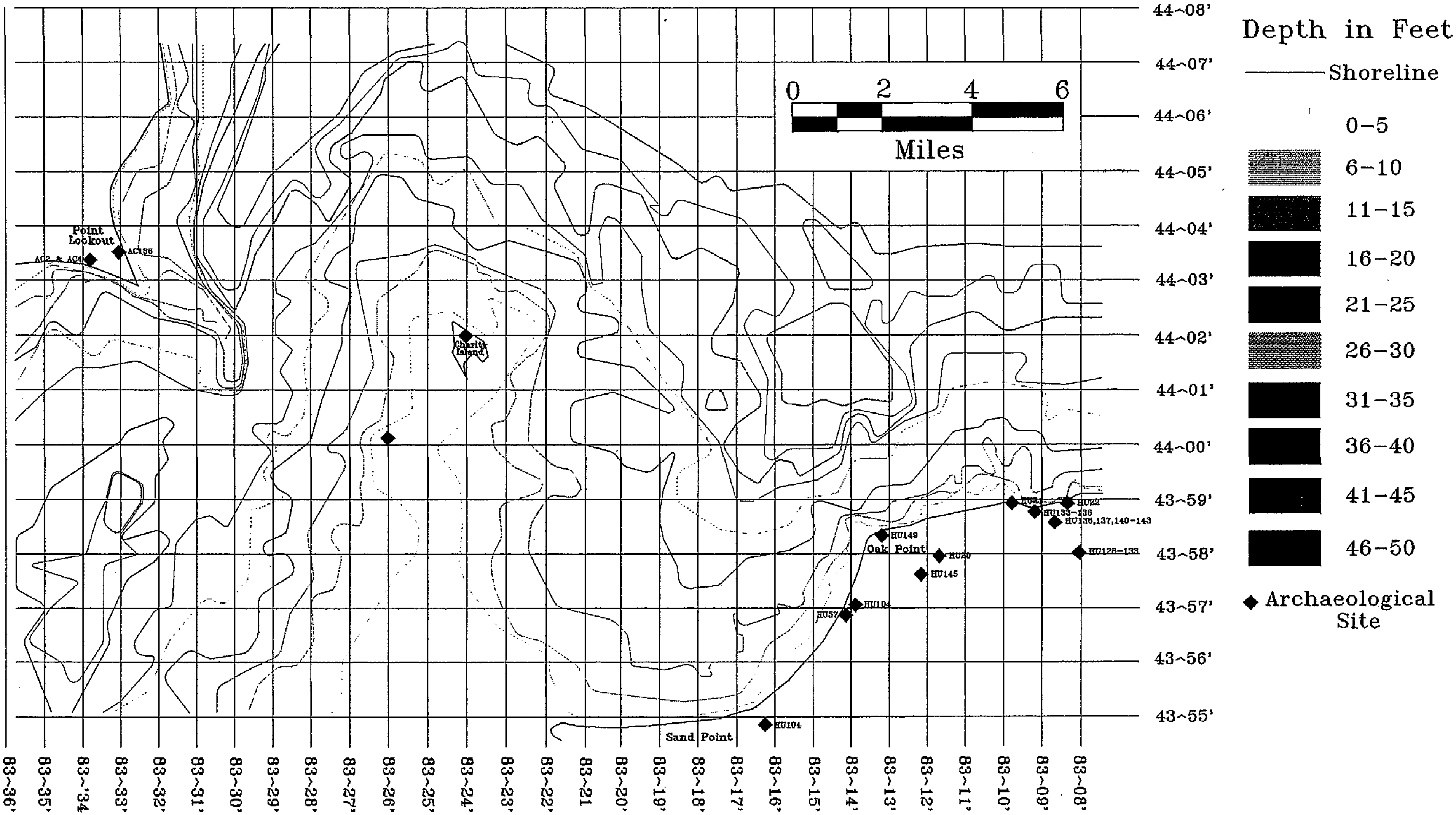
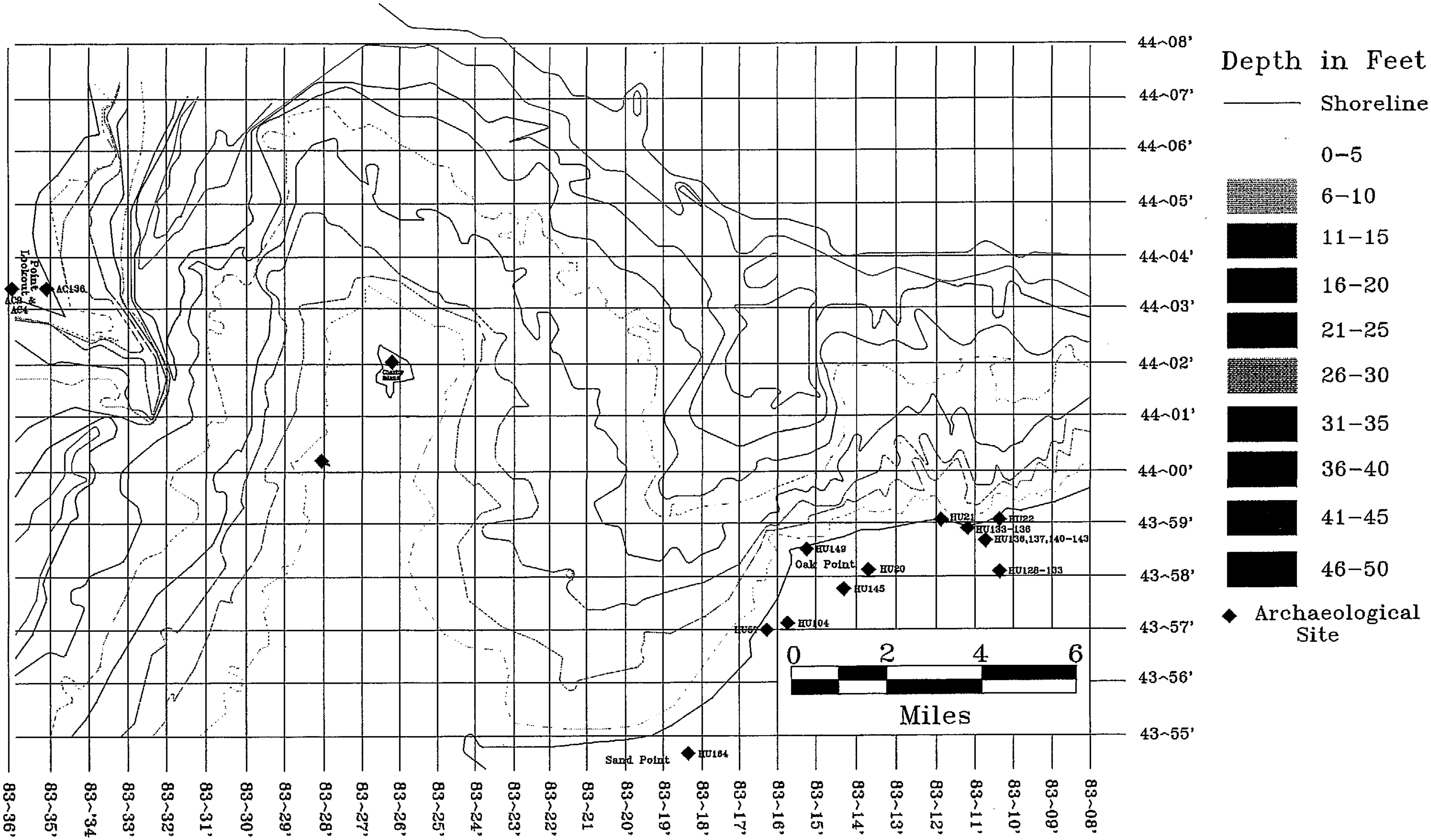


Figure 3 - Digitized 1987 Bathymetric Map of Outer Saginaw Bay Study Area displaying known archaeological site locations

Saginaw Bay Bathymetry - 1987



known points in time,

2) an assessment of the locational characteristics of recorded archaeological sites as they relate to both exposed and submerged topographic and drainage features, and

3) an assessment of sedimentation rates and regimes in terms of their ability to isolate high potential areas for the preservation of precontact archaeological sites on the bottomlands within the study area.

Each of these criteria will be treated in turn, and applied to the question of the types of discovery strategies and appropriate technologies necessary to explore for such sites on the Saginaw Bay bottomlands.

Bottomland Features

Assessment of submerged bottomland feature preservation and identification is central to this modeling exercise. If one takes a west to east transect across the study area several prominent submerged topographic features are evident at varying depths below the current water plane of about 580'. These include:

1) Lookout Point. Present day Lookout Point is a substantial bottomland feature displaying topographic integrity to at least 35 feet depth. Contour intervals reveal sharp relief to the east of the point, where the submerged channel of the Saginaw River departs the inner Saginaw Bay in its drainage to the Huron Basin proper, and shallow gradients to the south of the point. These relief differences are most likely a consequence of higher energy nearshore environments on the outer bay, and lower energy environments on the inner bay. Modern Lookout Point also

contains wetlands, although it is not currently possible to determine whether these are present on the bottomlands.

2) The Charity Islands and Vicinity. Crossing the submerged channel of the Saginaw River in the narrows between Lookout Point and the Charity Islands is a broad, relatively flat point or ridge extending approximately two miles north of Big Charity Island. The western margins of this ridge display sharp relief at a depth of approximately 25 feet, and the northern margins at a depth of 35 to 40 feet. Such depths for these features suggest an age of approximately 7000 B.P. based on estimated transgression rates. These zones of sharp relief appear to reflect river terracing from the Saginaw River on the west, and a submerged lake terrace on the north. Gradients to the east of Charity Island reflect a shallow and low relief submerged bay, evident at depths ranging from 6 feet to the south of Charity Island and near Sand Point, to depth in excess of 40 feet north of Oak Point. This bay is, in fact, the outlet of the submerged channel of the Quanicassee River, which parallels the southeast margin of Saginaw Bay for its entire length. The shallow gradients suggest a relatively low energy environment in the vicinity of the bay, and it should be noted that elevated beach terraces above the modern water plane also reflect the same contour configurations.

3) The Oak Point Vicinity. Oak Point defines the eastern margin of the submerged bay and outlet of the Quanicassee River. Oak Point is well defined on the bottomland contours of Saginaw Bay, with strong relief at depths which range from approximately 10 to 20 feet, but displaying a rather regular gradient overall.

Again, this is consistent with exposed contours above the modern water plane, which are also distinguished by upraised lake terraces.

Archaeological Site Locations

Archaeological site locations in the study area cluster in three primary locations, these include:

1) A group of three sites on Lookout Point, two on the south side, and one on the north side. Lookout Point is not unique in this regard across southern or northern Michigan. Such features are often associated with one or more precontact sites. In this instance the larger sites are located on the south side of the point, which would be considered the inner Bay, in the vicinity of the shallower bottomland gradients presumably reflecting lower energy environments. The location of Lookout Point on the western side of the submerged Saginaw River channel places it in a context also suggestive of high location potential; the outlet of a major stream into the lake basin.

2) The cluster of recorded sites on Big Charity Island, and a single known site on Little Charity Island, appear to be resource specific extractive locales. Exposures of limestone bedrock in both locations are associated with outcroppings of Bayport Chert, a primary raw material for stone tool manufacture in the region. These exposures are currently at the modern water plane for the Lake Huron basin, and can be traced offshore to varying shallow depths. The presence of bottomland contours at depths of approximately 20 feet suggest that submerged shoreline environments, in particular terraces, are present offshore of these modern site locations.

3) The Oak Point vicinity contains the largest cluster of archaeological sites in the study area. Two observations are noteworthy about this cluster. First, they occur at several locations around Oak Point; to the south, on the point proper, and to the east. This configuration would suggest that it is the larger locale of Oak Point that is being selected rather than a point specific location. Secondly, many of the sites present in the Oak Point cluster are present on interior beach ridges, often with intervening wetlands in the swales, reflective of periodically higher water elevations. The elevational "stacking" of archaeological sites on the west margin of the submerged bay and outlet of the Quanicassee River channel suggests that bottomlands offshore of known locations, particularly in high density areas such as 43 deg 59′ N, 83 deg 11′ W, should have high potential for submerged sites. This may be true of the bottomlands directly offshore of Oak Point proper as well.

<u>Sedimentation Rates and Regimes</u>

In large part our expectations for site preservation are premised on observations of stratigraphy on terrestrial archaeological sites. While Middle Archaic sites such as the Weber I site (Lovis 1989) demonstrate the potential for deeply buried deposits of Middle Holocene age to be present in the Saginaw Basin, an important observation that derives from this and other sites is the nature of the aquatic regimes which create such deposits. The Weber I deposits contain buried paleosols of several different ages, sealed by sterile sediments of two types; impounded backwater sediments of the wetlands in the Shiawassee Flats associated with higher-than-present base levels of the Huron basin, and alluvial deposits of the

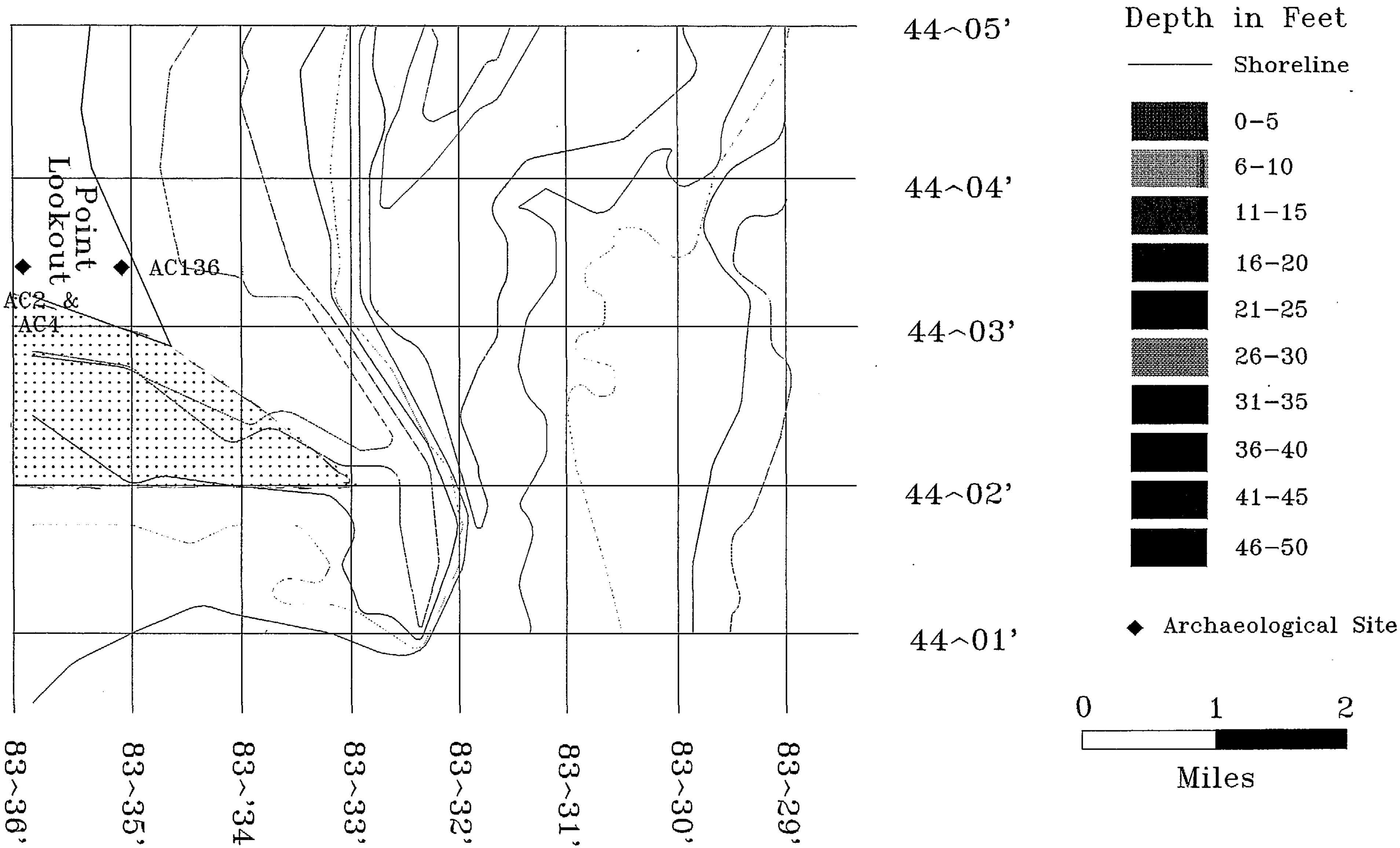
Cass River grading to higher base levels of the basin. Both sediment regimes resulted in minimal disruption of the cultural deposits on the paleosols, and demonstrate that specific types of larger scale transgressive events can result in sealed archaeological site preservation. A third type of regime is evident at the Ebenhoff site on the Shiawassee Flats, where the pulsating effects of Nipissing stage transgression and ultimately submersion of Middle Holocene deposits created a sealed and stratified sequence of peats and lacustrine sands with included cultural materials (Beaverson and Mooers 1993), revealing that lower energy environments on shallow gradient lake or wetland edges also have good potential for site preservation. This is precisely the type of sediment regime that can be expected on protected areas of the Saginaw Bay bottomlands. It is such analogs that contribute to the expectation that sites can be preserved in bottomland sediments of Saginaw Bay at specific locations.

To our knowledge this pilot study is the first research to employ the 1857 baseline bathymetrics from the initial surveys of Saginaw Bay in a comparative framework with modern bottomland data. Use of comparative baseline data was essential to initial modeling of sedimentation rates. Despite some evident inaccuracies in the 19th century survey data, articulated earlier in this report, it is possible to make some generalizations about the rates of sedimentation in those parts of the study area considered to have high site potentials.

1. Lookout Point (Figure 4) The Lookout Point vicinity reveals clear infilling of the submerged Saginaw River channel to the east of the point proper. In some instances deeper contours, those associated with depths greater than 35 feet, shift

Figure 4 - Lookout Point subarea displaying areas of sedimentation and submerged archaeological site potential

Saginaw Bay Bathymetry 1987 (West)



northward a full minute of latitude revealing sedimentation accumulation of greater than 10 feet on the bottomlands in the past 130 years. The northeast side of the point reveals that bottomland contours do not change position markedly. The bottomlands in this area have apparently sustained rather regular bottom depths since the 19th century survey, perhaps as a consequence of similar offshore current, prevailing wind, and wave regimes.

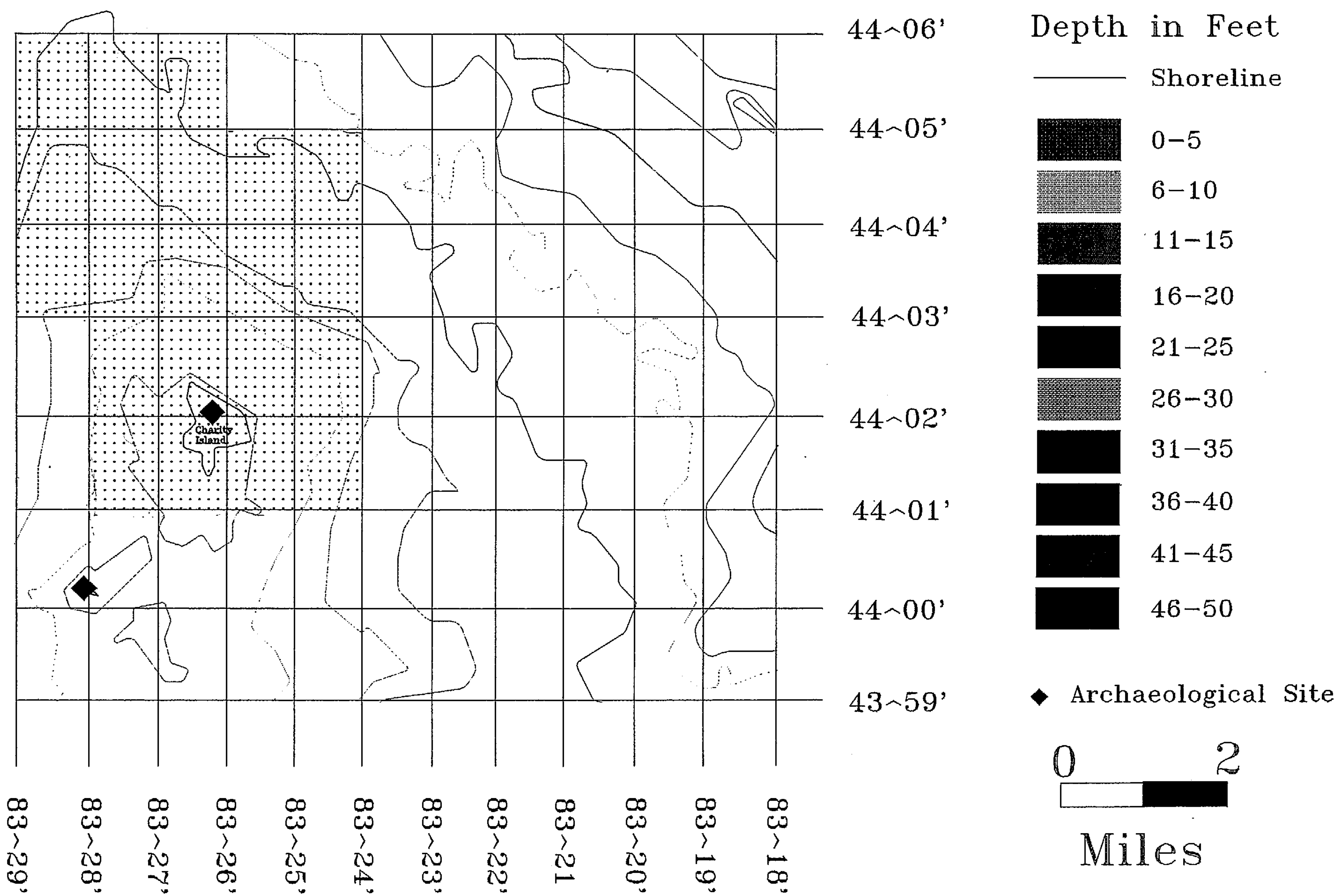
South of Lookout Point, however, a different set of circumstances is present. In particular, the 21'-25' depth contour shifts southward a full 0.5 minutes of latitude. This is suggestive of higher depositional rates in this vicinity, perhaps with accumulations of 5 feet or more in the past 130 years. It is possible that this area may preserve sites in sealed sediments.

2. <u>The Charity Island Vicinity</u> (Figure 5) Addressing first the sedimentation rates north of Big Charity Island, it is evident that substantial deposition has taken place within the past 130 years. In 1857 contours in the 5' to 10' depth range were positioned closely adjacent to the north side of the island, whereas in 1987 these contours had moved north a full minute of latitude, or more than one half mile. This is true of deeper contours as well, with the 1857 21'-25' depth contour about 1.5 minutes north of the island, and the same contour in 1987 positioned 2.6 minutes north of the island. This reveals between 5 and 10 feet of sedimentation north of Charity Island in the past 130 years.

The same phenomenon holds for areas to the west of the Charity Island vicinity as well, where the 21'-25' foot contour lies about 3 minutes west in 1857,

Figure 5 - Charity Island subarea displaying areas of sedimentation and submerged archaeological site potential

Saginaw Bay Bathymetry 1987 (Center)



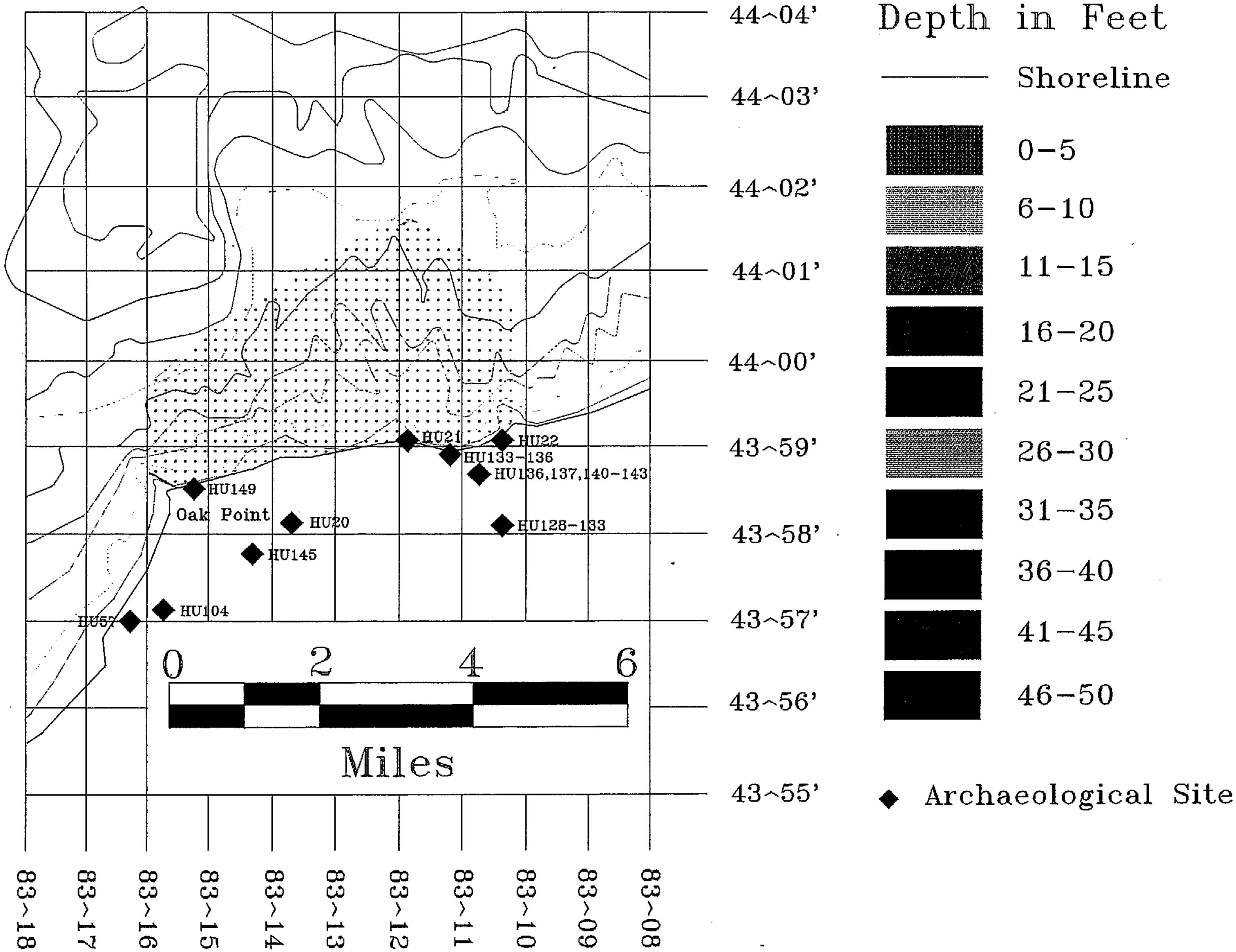
and 3.7 minutes west in 1987, suggesting similar sedimentation rates. To the east, there is not much spatial movement of the bottomland contours revealing similar elevations overall, and an inability to determine whether aggradation or degradation has occurred.

3. <u>The Oak Point Vicinity</u> (Figure 6) There are, in fact, three components of the Oak Point vicinity site distribution that warrant comment here. The area directly north of Oak Point proper, for example, does not experience significant variation in bottomland contours to suggest sediment accumulation on a magnitude that would warrant further inspection. The large cluster of sites to the east of Oak Point, however, bears further scrutiny. The bottomland contours in this vicinity move northward in excess of 0.25 miles, revealing greater sediment accumulation here than further to the west. This phenomenon is also true offshore of the pair of sites south of Oak Point where, in particular, the 11'-15' foot depth contour shifts westward almost a full minute of longitude.

The sediment regimes for the Saginaw Bay are not easily reconstructed due to a general lack of deep cores. Most "coring" strategies have, in fact, been shallow grab samples of surficial bottom sediments. However, inspection of a series of cores from both the inner and outer Bay was made possible by Dr. Grahame Larson of the Department of Geological Sciences at Michigan State University from work he performed with Dr. David Long of MSU. This core series was drawn in 1995, and represents the best deep core sample and most recent data available on sediment regimes. Several observations made on these cores are pertinent to the present

Figure 6 - Oak Point subarea displaying areas of sedimentation and submerged archaeological site potential

Saginaw Bay Bathymetry 1987 (East)



project, as are the comments of Dr. Larson.

First, preserved, intact surfaces are apparently present and recoverable from the bottomlands of Saginaw Bay. At least one of the cores, from inner Saginaw Bay, displayed stratigraphy interpretable as a pre-Nipissing stable soil surface, overlain by wetland formations such as peat and wood, which in turn was overlain by Nipissing age sediments. This suggests that under the proper conditions intact soil surfaces are still present and are recoverable. Secondly, there is a major sedimentological difference between the inner Saginaw Bay, inside of the Charity Islands, Lookout Point, and Oak Point, and the outer Saginaw Bay. The inner Saginaw Bay sediment regime is composed primarily of finer grained sediments such as silts and clays. These sediments are readily recoverable from cores and present relatively intact core profiles. The outer Saginaw Bay presents a sequence dominated by coarser grained sediments such as sands. Great difficulty was encountered by the Michigan State University Department of Geological Sciences team in successfully drawing intact cores from this sediment regime, suggesting that a somewhat different sampling/coring approach might be necessary on the outer margins of the Bay. Notably, some of the areas of high likelihood for preserved surfaces are in the outer Bay, and it will be necessary to accomodate this problem in future work.

Implications for Future Research

From this pilot research it is clear that there are preserved identifiable topographic features that predate the Middle Holocene age Lake Nipissing Stage inundation of the study area, and that there is potential for the preservation of intact occupiable surfaces in three parts of the study area; north of Big Charity Island, south of Lookout Point, and off the south margin of Oak Point. Additionally, such surfaces are recoverable, at least on the inner Bay, through systematic coring, while on the outer Bay i.e. north of Big Charity Island, non-standard coring techniques might be necessary. Datable materials in the form of both peat and wood are likely to be present, thereby providing chronological control on the age of such surfaces. Significantly, all of the data collected reveal that surface inspection techniques such as remote operating vehicles (ROV's) equipped with videocameras <u>will not</u> be appropriate to the work that is necessary if employed alone. Rather, it is essential that both remote and physical sub-bottom sampling be performed.

<u>Conclusions</u>

Based upon the survey of technology vendors presented in the Appendix, it becomes clear that it will be essential to employ both remote and physical sub-bottom sampling. The recommendations derived from the vendor survey reveal that systems such as Ground Penetrating Radar (GPR), Side Scan Sonar, and Sector Scanning Sonar applied in conjunction with an video equipped ROV are the most informationally useful approaches given the conditions of the Saginaw Bay study area. The primary question about use of such systems is data quality. It is possible that GPR in particular may result in poor quality or difficult to interpret graphic and numerical information. Vrana is of the opinion that if that is the case then CHIRP systems may be more appropriate.

The implications of the foregoing discussion are several, and suggest that any future work might best be conducted in at least two and possibly more stages. The first of these would involve some form of sub-bottom profiling across high potential areas to reveal bottom stratigraphy. The first choice for such work would be Ground Penetrating Radar, with sonars a second choice, and lastly a CHIRP system. In part this will be an assessment stage to determine which of these systems works best in the local conditions of Saginaw Bay. It is recommended that these be employed in conjunction with a video equipped ROV primarily as a means of assessing bottom topography, not as a means of searching for submerged sites. The primary goal of this stage would be to further refine data related to the presence and spatial distribution of both topographic and stratigraphic features, and would serve to focus the next phase of the project.

The second major stage should consist of systematic coring in a series of discrete sampling areas defined on the basis of sub-bottom data collected using GPR, sonar, or CHIRP systems. The primary goal of this stage would be the recovery of stratigraphic data from high potential areas. It appears that the technology most appropriate to this task is some form of vessel-based vibracore apparatus, spatially deployed using global positioning systems. An ancillary but clearly desirable goal of this stage would be the attempted recovery of culturally identifiable materials from these high potential areas, including but not limited to lithic detritus, and faunal and floral remains. The success of this stage is wholly dependent upon the specific nature of bottom sediments, i.e. their consolidation, and the density of cultural materials that might be present in any given sample location. The statistical success of such discovery strategies are easily modeled using variables such as core interval, core diameter, and suspected artifact density.

In sum, it is clear that preserved landforms with high potential for preserved stratigraphy, and consequently the potential for preserved archaeological sites, are present across the mouth of Saginaw Bay. Sampling for the discovery and recovery of submerged archaeological sites in Saginaw Bay will not be a straightforward process, but will of necessity have to rely on refined bottom sampling technologies.

REFERENCES CITED

Anuskiewicz, Richard J.

1988 Preliminary Archaeological Investigations at Ray Hole Spring in the Eastern Gulf Of Mexico. The Florida Anthropologist 41(1):181-185.

Arnold, Jeanne E.

1977 Early Archaic Subsistence and Settlement in the River Raisin Watershed, Michigan. Appendix II in The River Raisin Archaeological Survey Season 2, 1976: A Preliminary Report by Christopher S. Peebles and James J. Krakker. A report to the Michigan History Division, Michigan Department of State from Division of the Great Lakes, Museum of Anthropology, University of Michigan, Ann Arbor.

Beaverson, S.K. and H.D. Mooers

1993 Reconstruction of the Late Glacial and Holocene Paleoenvironmental Setting at 20SA596, Saginaw Valley, Michigan. Reports of Investigations No. 210. Institute for Minnesota Archaeology, Minneapolis. Submitted to Braun Intertec Environmental, Inc. and Great Lakes Gas Transmission, Ltd.

Blawatsky, Vladimir D.

1972 Submerged Sectors of Towns on the Black Sea Coast. Underwater Archaeology:A Nascent Discipline. UNESCO, Paris, pp.115-122.

Bocquet, Aime

1979 Lake-Bottom Archaeolgy. Scientific American 240(2):56-64.

Bretz, J. H.

1951 Causes of the Glacial Lake Stages in the Saginaw Basin, Michigan. Journal of Geology 59:244-258.

Butterfield, Ira W.

1986 Water Configurations in the Human Environment from the Main Algonquin to the Nipissing I Stages of the Great Lakes in the Saginaw Valley, Michigan. The Michigan Archaeologist. 32(3):101-137.

Cockrell, Wilburn A.

1980 Drowned Sites in North America. Archaeology Under Water An Atlas of the World's Submerged Sites. k. Mucelroy, ed., McGraw-Hill Book Co., New York, pp.138-145.

1986 Inundated Terrestrial Sites in North America. Underwater Archaeology: The Proceedings of the 14th Conference on Underwater Archaeology, C.R. Cummings, ed., Fathom Eight, San Marino, CA., pp. 49-57.

Diving Times
1990 Illinois Underwater "Forest" Discovered. The Journal of Great Lakes Sport Diving, p. 8.

Dunbar, James S.
1988 Archaeological Sites in the Drowned Tertiary Karst Region of the Eastern Gulf of Mexico. The Florida Anthropologist 41(1):177-181.

Emery, K.O. and R. L. Edwards
1966 Archaeological Potential of the Atlantic Continental Shelf. American Antiquity 31(5):733-737.

Farrand, W. F. and D. Eschman
1974 Glaciation of the Southern Peninsula of Michigan: a Review. Michigan Academician 7:31-56.

Faught, Michael
1988 Inundated Sites in the Apalachee Bay Area of the Eastern Gulf of Mexico. The Florida Anthropologist 41(1):185-190.

Fitting, James E.
1975 The Archaeology of Michigan. Second Edition. Cranbrook Institute of Science, Bloomfield Hills.

Flemming, Nicholas C.
1980 Cities Under the Mediterranean. Archaeology Under Water An Atlas of the World's Submerged Sites. K. Muckelroy, ed., McGraw-Hill Book Co., New York, pp. 162-177.

1985 Ice Ages and Human Occupation of the Continental Shelf. Oceanus 28(1):18-25.

Frost, Honor
1972 Ancient Harbours and Anchorages in the Eastern Mediterranean. Underwater Archaeology: A Nascent Discipline. UNESCO, Paris, pp.95-114.

Fullerton, D. S.
1980 Preliminary Correlation of Post-Erie Interstate Events (16,000 10,000 radiocarbon years before present), Central and Eastern Great Lakes

Region, and Hudson, Champlain, and St. Lawrence lowlands, United States and Canada. U.S. Geological Survey, Professional Paper 1089.

Galili, Ehrud, D. Kaufman and M. Weinstein-Evron
1988 8,000 Years Under the Sea. Archaeology 41(1):66-67.

Goggin, John M.
1960 Underwater Archaeology: Its Nature and Limitations. American Antiquity 25(3):348-354.

Halsey, John R.
1990 Beneath the Inland Seas Michigan"s Underwater Archaeological Heritage. Bureau of History, Michigan Department of State, Lansing.

Hamilton, D. L.
1986 Port Royal Revisited. Underwater Archaeology: The Proceedings of the 14th Conference on Underwater Archaeology, C.R. Cummings, ed., Fathom Eight, San Marino, CA., pp. 73-77.

Holman, J. Alan
1990 Vertebrates from the Harper Site and Rapid Climatic Warming in Mid-Holocene Michigan. Michigan Academician XXII(3):205-217.

Holman, J. Alan, D.C. Fisher, and R.O. Kapp
1986 Recent Discoveries of Fossil Vertebrates in the Lower Peninsula of Michigan. Michigan Academician 18:431-463.

Horvath, Frank J.
1987 Saginaw Bay Bathymetry. Great Lakes Information System Division of Land Resource Programs, Michigan Department of Natural Resources, Lansing.

Hough, J. L.
1958 Geology of the Great Lakes. University of Illinois Press, Urbana, Illinois.

Karrow, P. F.
1980 The Nipissing Transgression Round Southern Lake Huron. Canadian Journal of Earth Sciences 19:1271-1275.

Kapp, R. O., S. G. Beld and J. A. Holman
1990 Paleontological Resources of Michigan: An Overview. In R.W. Stoffle (Editor), Cultural and Paleontological Effects of Siting a Low-Level Radioactive Storage Faciltiy in Michigan. Institute for Social Research,

University of Michigan. Ann Arbor.

Keene, Arthur S.
1981 Prehistoric Foraging in a Temperatte Forest: A Linear Programing Model. Academic Press, New York.

Larsen, Curtis E.
1985 Geoarchaeological Interpretation of Great Lakes Coastal Environments. Archaeological Sediments in Context. J.K. Stein and W.R. Farrand eds., Center for the Study of Early Man, Institute for Quaternary Studies, University of Maine at Orono, pp. 91-110.

Leverett, F., and F. B. Taylor
1915 The Pleistocene of Indiana and Michigan and the History of the Great Lakes. U.S. Geological Survey, Monograph 53.

Lewis, C. F. M.
1969 Late Quaternary History of Lake Levels in the Huron and Erie Basins. Proceedings: l2th Conference, Great Lakes Research, pp. 250-270. International Association for Great Lakes Research.

1970 Recent uplift of Manitoulin Island, Ontario. Canadian Journal of Earth Sciences 7:665-675.

Lovis, William A.
1986 Environmental Periodicity, Buffering, and the Archaic Adaptations of the Saginaw Valley of Michigan. In Foraging, Collecting and Harvesting, Archaic Period Subsistence and Settlement in the Eastern Woodlands, edited by S. Neusius. Southern Illinois University at Carbondale, Center for Archaeological Investigations, Occasional Paper, No. 6, pp. 99-116.

1989 Variations in Late Archaic Resources Availability as a Consequence of Lake level Periodicity in the Huron Basin. Paper presented at the 54th Annual Meeting of the Society for American Archaeology. On file at the Michigan State University Museum, East Lansing.

1989 Archaeological Investigations at the Weber I and Weber II Sites, Frankenmuth Township, Saginaw County, Michigan. Michigan Cultural Resource Investigation Series, Vol. 1. State of Michigan, Lansing.

1990 The Potential Impacts of Environmental Periodicity on Late Archaic Lacustrine Adaptations in the Saginaw Valley of Michigan. Paper presented for symposium entitled Hunter/Gatherer Lacustrine

Adapatations at the 55th Annual Meeting of the Society for American Archaeology. On file at the Michigan State University Museum, East Lansing.

n.d. The Early and Middle Archaic. Contribution to Retrieving Our Buried Past: The Archaeology of Michigan. John R. Halsey, editor. In press.

Lovis, W.A. and K.C. Egan, W.G. Monaghan, B.A. Smith, E.J. Prahl
1989 Environment and Subsistence at the Marquette Viaduct Locale of the Fletcher Site. Research report submitted to the National Geographic Society. On file at the Michigan State University Museum, East Lansing.

Lovis, W.A. and M.B. Holman, W.G. Monaghan, R.K. Skowronek
1994 Archaeological, Geological, and Paleoecological Perspectives on Regional Research Design in the Saginaw Bay Region of Michigan. In Great Lakes Archaeology and Paleocology: Exploring Interdisciplinary Initiatives for the Nineties, Proceedings of a Symposium presented by the Quaternary Sciences Institute, University of Waterloo, Waterloo, Ontario, September 21-22, 1991 Robert I. MacDonald, ed. Quaternary Sciences Institute, Waterloo.

Macomb, J.N. and G.G. Meade
1860 Saginaw Bay and Part of Lake Huron. Bureau of Topographical Engineers of the War Department of the United States. 1:120,000. Rare maps collection, State of Michigan Library, Lansing.

Marx, Robert F.
1972 The Submerged Remains of Port Royal, Jamaica. Underwater Archaeology: A Nascent Discipline, UNESCO, Paris, pp. 139-145.

1980 The Sunken City of Port Royal. Archaeology Under Water An Atlas of the World's Submerged Sites K. Muckelroy, ed., McGraw-Hill Book Co., New York, pp.146-147.

Mason, Ronald J.
1981 Great Lakes Archaeology. Academic Press, New York.

Masters, Patricia M.
1985 California Coastal Evolution and the La Jollans. Oceanus 28(1):27-42.

Monaghan, G. W.
1986 Geology of the Third Street Bridge Right of Way. In Archaeological Investigations at Sites 20BY77, 20BY78, and 20BY79, at the Third Street Bridge Replacement, Bay City, Michigan (edited by W. Lovis), pp. 45-52). Report submitted to the Michigan Departments of State and Transportation. Michigan State University. East Lansing.

Monaghan, G. W., L. Fay and W. Lovis
1986 Nipissing transgression in the Saginaw Bay region, Michigan. Canadian Journal of Earth Sciences, 23(11): 1851-1854. Ottawa.

Morrison, Ian A.
1980 Man-made Islands in Scottish Lochs. Archaeology Under Water, An Atlas of the World's Submerged Sites, K. Muckelroy, ed., McGraw-Hill Book Co., New York, pp. 156-161.

Peebles, Christopher S. and James J. Krakker
1977 The River Raisin Archaeological Survey Season 2, 1976: A Preliminary Report by Christopher S. Peebles and James J. Krakker. A report to the Michigan History Division, Michigan Department of State from Division of the Great Lakes, Museum of Anthropology, University of Michigan, Ann Arbor.

Raban, Avner
1985 Marine Archaeology in Israel. Oceanus 28(1):59-65.

Raban, Avner, editor
1988 Archaeology of Coastal Changes. Proceeding of the First International Symposium "Cities on the Sea-Past and Present." B.A.R. International Series #404, Oxford, England.

Robbins, John A.
1986 Sediments of Saginaw Bay, Lake Huron: Elemental Composition and Accumulation Rates. Special Report No. 102 of the Great Lakes Research Division, Great Lakes and Marine Waters Center, University of Michigan, Ann Arbor.

Robertson, James A.
1987 Inter-assemblage Variability and Hunter-Gatherer Settlement Systems: A Perspective from the Saginaw Valley of Michigan. Ph.D. Dissertation, Department of Anthropolgoy, Michigan State University, East Lansing.

Ruoff, Ulrich

1972 Palafittes and Underwater Archaeology. Underwater Archaeology: A Nascent Discipline, UNESCO, Paris, pp. 123-127.

1980 Alpine Villages on Stilts. Archaeology Under Water, An Atlas of the World's Submerged Sites, K. Muckelroy, ed., McGraw-Hall Book Co., New York, pp.148-155.

Ruppe, Reynold J.

1980 The Archaeology of Drowned Terrestrial Sites: A Preliminary Report.Bureau of Historic Sites and Properties, Bulletin No. 6, Division of Archives, History and Records Management, Florida Department of State, Tallahassee, pp.23-45.

Scott, Linda J.

1986 Pollen in Underwater Sediments:Sea-Level Change and Environmental Transition. Underwater Archaeology:The Proceedings of the 14th Conference on Underwater Archaeology. Calvin R. Cummings, editor, Fathom Eight Spcial Publication #7, San Marino, CA..

Serbousek, Don

1988 An Example of an Offshore Sinkhole in the Gulf of Mexico with Good Archaeological Potential. The Florida Anthropologist 41(1):190-191.

Shiner, Hoel L.

1986 Prehistory Underwater. Underwater Archaeology: The Proceedings of the 14th Conference on Underwater Archaeology, C.R. Cummings, ed., Fathom Eight, San Marino, Ca., p. 138.

Shott, Michael J. and Paul D. Welch

1984 Archaeological Resources of the Thumb Area of Michigan. The Michigan Archaeologist 30(1):1-80.

Smith, Beverley A. and Kathryn C. Egan

1990 Middle and Late Archaic Faunal and Floral Exploitation at theWeber I (20SA581) Site, Michigan. Ontario Archaeology. 50:39-54.

Speth, John D.

1972 Geology of the Schultz site. In The Schultz site at Green Point: A Stratified Occupation Area in the Saginaw Valley of Michigan, edited by James E. Fitting. Museum of Anthropology, University of Michigan, Memoir 4:53-75.

Wendland, Wayne M.
1978 Holocene Man in North America: The Ecological Setting and Climatic Background. Plains Anthropologist 23-82(Pt. 1):273-287.2

APPENDIX

ASSESSMENT OF UNDERWATER TECHNOLOGIES

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INTRODUCTION

The U.S. Congress Office of Technology Assessment (OTA) (1986:72) concluded that "underwater archaeology is highly dependent on advanced technology, and that a research design is extremely important in determining the appropriate technology to apply to the study of underwater cultural resources." These conclusions affirm the need for more scientific approaches to the assessment and use of technology.

Three goals were defined for *phase one* of the Saginaw Bay Archaeological Project. This section of the report provides an assessment of underwater technologies as defined by the *third goal* of phase one. The assessment is based on evaluative criteria that include the predicted archaeological site locations, operational conditions, and functional requirements.

Specific components of the goal to assess underwater technologies include:

1. the development of *evaluative criteria* to assist in the exploration, identification, and management of submerged terrestrial sites on the bottomlands;
2. assessment of the technologies available for *site reconnaissance and discovery* based upon the foregoing data; and
3. consultation with manufacturers and vendors of such equipment to determine the *most appropriate currently available technologies* for field tests and applications.

The assessment of underwater technologies and identification of most appropriate technologies should be "a logical process of activities which transforms a set of requirements arising from a specific mission objective into a full description of a system which fulfills the objectives in an optimum way" (Skytte 1994). Based on this definition and project goals, the technology assessment process should involve the following steps:

1. definition of remote-sensing objectives and operational conditions;
2. determination of functional requirements for technology systems;
3. definition of technical specifications based on those requirements;
4. identification and assessment of appropriate currently available technologies; and
5. recommendation of a technology system.

The definition of technical specifications for appropriate technologies is best completed through close consultation among principle investigators and the representatives and technicians of undersea development and service corporations. Because of a general lack of information on sub-bottom characterization of cultural materials in the Great Lakes, many technical specifications will remain undefined until the next phase, or will be stated in general terms rather than specific mathematical values.

REMOTE-SENSING OBJECTIVES

The primary purposes of remote-sensing operations in the Saginaw Bay Archeological Project are reconnaissance of submerged lands and site discovery as predicted. The process of reconnaissance in this case includes assessment of sub-bottom stratigraphy and submerged topography for the potential presence of prehistoric cultural materials.

The objectives of these remote-sensing operations can be defined as follows:

1. locate surfaces of ancient landforms (e.g., beach terraces, coastal shorelands);
2. locate archaeological site features on (or within) the surfaces of the ancient landforms; and
3. remove and analyze core samples from the lake bottomlands.

Operations will include the use of boats outfitted with remote-sensing technologies and systems. It may involve also direct physical techniques of observation and measurement using scuba (self-contained underwater breathing apparatus) and deployment of technologies through ice if appropriate.

The meaning of remote-sensing varies by discipline but can be defined simply as "the observation and measurement of an object without touching it" (Curran 1985:1). Engineers and geophysicists consider remote sensing to be the "examination of earth features from a distant platform situated above the target area" (Heimmer 1992:3). It is commonly associated with the use of electromagnetic radiation sensors and aerial platforms to produce images of environmental features that are interpreted for purposes in scientific research and resource management. A distinction can be made between remote-sensing and the use of geophysical methods that measure subsurface physical contrasts. Geophysical surveys normally require contact or near contact between the sensor and the earth's surface (Heimmer 1992).

For the purposes of this assessment, the term remote-sensing will include geophysical methods.

In underwater or undersea applications, remote-sensing is commonly associated with the use of acoustic waves (e.g., fathometers, echosounders, side-scan sonars, sub-bottom profilers) and force fields (e.g., magnetometers) to characterize and assess submerged lands (OTA 1986). Fathometers, echosounders, and side-scan sonars can produce images of environmental or cultural features within the water column and on the surface of submerged lands. Sub-bottom profilers can produce images of environmental or cultural features buried within submerged lands. Magnetometers can detect certain materials buried within submerged lands.

Laser technology is now being applied effectively to produce high resolution characterization of surface features on submerged lands. Laser systems provide optical imaging to survey large areas of submerged lands. Ground penetrating radar (GPR), an electromagnetic technology, has been applied relatively recently in archaeology and within freshwater environments to produce sub-bottom profiles with some success (Heimmer 1992). Unfortunately, there is a lack of scientific studies in maritime archaeology and resource management that have used GPR as a remote-sensing technology. Heimmer (1992:48) believes that "the penetration capabilities of radar in the freshwater environment offers the archaeologist an excellent exploratory method for investigating submerged sites."

Many of these technologies are designed for deployment from small boats. Sonar technologies are sometimes deployed also from remotely-operated vehicles

(ROVs).

EVALUATIVE CRITERIA

Predicted Site Locations

Prehistoric terrestrial sites from 5000 - 9000 B.P. are believed to be located in Saginaw Bay near Point Lookout, Little Oak Point, and North Charity Island. These predictions are based on the bathymetry of the upper region of Saginaw Bay (1857 and 1987) and the location of present-day coastal archaeological sites. Sedimentation rates and regimes indicate that these *sites will be under 10 feet or more of sediments.*

These sites are probably associated with ancient landforms. The landforms may be distinguishable as changes in sediment density (probably increased density) and graphic indications of buried soil horizons, or large point features (i.e., tree stumps, rocks). Sediment stratigraphy may include peat and other organic soils. Archaeological site features could include placed stone, fish bones, pits or depressions, and surface hearths with burned materials. Pits or depressions may measure 3 - 4 feet wide and 2 - 3 feet deep.

Operational Conditions

Saginaw Bay is a large, shallow bay extending southwest from the southern Lake Huron basin. Some predicted site locations are protected from winds out of the northwest; other locations are protected from winds out of the southeast. All sites are exposed to the prevailing southwest winds of May - September. Nearby harbors include Port Austin, Caseville, East Tawas, and Au Gres, Michigan.

The operational conditions expected at the predicted site locations include the following:

- The maximum depth of freshwater to bottom sediments is 30 feet.
- Water visibility is estimated at 5 - 10 feet; visibility is lower with storm surge and other disturbances of bottomland sediments. Water visibility improves generally during winter months with decreases in primary productivity (i.e. phytoplankton populations) (Dolan et al. 1986).
- The average time of freeze-up at Point Lookout for 1965 - 79 was the last week in December. The average time of maximum ice thickness (46 cm average maximum) was the third week in February. The average time of ice breakup was the last week in March (Bolsenga et al. 1988).
- Approximately 10 feet or more of sediments need to be cored. Bottomland sediments may range from soft, unconsolidated materials to well-consolidated materials.

Functional Requirements

Important functional requirements to consider in determination of appropriate technologies are based on the project purposes, objectives for remote-sensing operations, predicted site locations, and operational conditions. These functional requirements and some general technical specifications include:

1. Platform Technologies

- small boat(s) that can operate in depths from 5 - 30 feet of freshwater

- sufficient enclosed cabin space to adequately protect electronic equipment and comfortably accommodate 1 - 2 system operators and 1 - 2 researchers
- power supplies that allow long periods of continuous survey operations, especially to take advantage of good weather and sea conditions
- navigation system(s) that provide precise positioning of the boat and rapid updates of position (near real-time) for close adherence to survey transects. The system should provide a graphic output for the boat operator to easily make course corrections, and for the researcher to verify adherence to survey transects.

2. Remote-Sensing Technologies

- self-contained and capable of easy deployment so that different boats of opportunity can be used for survey
- durable and waterproof to withstand boat operations
- robust imaging capabilities that allow characterization of a variety of surface and sub-bottom features
- 2-dimensional image field and target resolution; 3-D is optional, but is probably beneficial for interpretation of surface features
- adequate resolution to easily interpret surface features on submerged lands that are associated with ancient landforms
- adequate resolution to interpret sub-bottom features, discontinuities, or

anomalies associated with cultural materials

- precision to measure surface features in meters
- precision to measure sub-bottom features in centimeters
- capability for efficient visual inspection and electronic post processing of data
- compatibility to easily convert data to spacial information systems and electronic databases

3. Underwater Coring Technologies

- deployable from small boats
    - capability for retrieving cores from unconsolidated and consolidated sediments

IDENTIFICATION AND ASSESSMENT OF APPROPRIATE TECHNOLOGIES

Literature Review

Appropriate technologies discussed by the OTA (1986:57-58, 69-70) and Heimmer (1992:8-16, 37-43, 47-48) for underwater archaeology and resource management include magnetometers, side-scan sonars, precision fathometers, sub-bottom profilers, ground penetrating radars, and electronic positioners. Information for selected technologies is excerpted, summarized, and updated below. These include both passive and active, non-destructive technologies and associated methods. Passive methods involve "measurements of naturally occurring local or planetary fields created by earth related processes. . . . Active methods involve the transmission of an electrical, electromagnetic, or acoustic signal into the water or subsurface" (Heimmer 1992:5-6). Generally, the longer the wavelength that is transmitted, the greater is its ability to penetrate the subsurface. But, longer wavelengths generally result in less image resolution.

- *Magnetometers* passively sense the magnetic field anomalies created by ferrous materials and other discontinuities on submerged lands or buried in shallow sediments. Its major shortcoming is that the sensors must be deployed relatively close to their targets because the targets' magnetic fields attenuate rapidly. Other limitations include magnetic noise from recent cultural materials, certain geologic conditions, and solar activity. Magnetometers can be deployed by boats or planes.
- *Side-scan sonars* transmit acoustic pulses from an instrument (i.e., towfish) usually deployed behind a survey boat. A receiver on the towfish or boat detects the reflected signal and creates a graphic image of submerged lands and features located on its surface. Images are based on the return time and direction of each reflected signal. These systems are readily available and enable the quick and accurate characterization of submerged lands.
- *Laser scanning* is an active, optical method that does *not* have the capability of subsurface penetration. It can be viewed as a water equivalent to aerial photography. This system is designed for deployment from boats to produce high resolution panoramic surveys at rapid area coverage rates, real time data monitoring, and storage of

digital images for post processing and analysis (Mooradian et al. 1993). Aerial laser scanning systems can image submerged lands through shallow, clear waters.

- *Sub-bottom profilers* are sonar instruments that generate acoustical pulses downward. These pulses are reflected back from sediment layers below the surface of submerged lands. Each sediment layer produces a discrete echo that is received and printed on strip charts or other media. They are limited to surveying only the area directly beneath the survey boat.

  Recent developments in acoustic sub-bottom profiling have resulted in chirp systems. Chirp utilizes the transmission of calibrated, swept FM waveforms, combined with matched filter sonar algorithms to allow interpretation of sub-bottom layers and objects hundreds of feet below submerged lands. An example of a chirp profile is found in Attachment A.

- *Ground penetrating radar* is an active electromagnetic subsurface method. It introduces an electromagnetic signal, generally in the 80-1000 megaHertz range, into the ground or through freshwater from a transmitting antenna. This signal then travels back to a receiving antenna. The signal time delay, magnitude or amplitude, phase (negative or positive), and frequency of the received signal provides information and images of the subsurface materials. An example of a

GPR profile is found in Attachment B.

- *Remotely-operated vehicles (ROVs)* are robotic platforms tethered, powered, and controlled from the survey boat. They can be equipped with specialized work packages (e.g., manipulator arms, water jet and suction systems, sampling devices, navigation instruments, side-scan and sector-scanning sonar). ROVs are available from a number of vendors as standard models and for specialized purposes in a variety of sizes. These vendors will often customize a standard model for specialized applications.
- *Loran and Global Positioning Systems (GPS)* are available for Saginaw Bay and have accuracy and reliability to within approximately 30 - 100 feet. GPS appears to have better accuracy and reliability. For greater precision, some portable positioning systems (e.g., Motorola Mini-Ranger Falcon) can be installed on land, but are expensive to lease and maintain.

Side-scan sonar systems and sub-bottom profilers can produce real-time survey images on chart paper or color monitors, and provide digital outputs for computer enhancement and interpretation of data. Magnetometers and ground penetrating radar have more limited real-time formats (i.e., graphic strip chart plots) but GPS data can be acquired on magnetic tape and input to a computer for enhancement and display in other formats for interpretation. Other types of hydro-acoustic processors are becoming available to discriminate among lake bottom materials and that output the data acquired in a format ready for instant computer analysis (Murphy et al. 1995).

Expert Opinion

Method:

About a dozen experts in sub-bottom or subsurface survey were identified and contacted by phone. These experts included undersea engineers, product managers, technology development specialists, and maritime archaeologists with experience in sub-bottom survey. They were then faxed a two-page summary of project goals and objectives, predicted site locations, and operational conditions. Based on information from the fax summary and phone conversations, these experts identified and provided opinions about various technologies they believe are needed to successfully meet project goals and objectives. Some of these individuals provided also product and service information, reports, and technical articles about these technologies. This written information and notes from phone conversations are summarized in the following sections on results. Expert opinions focused on sub-bottom characterization, but included also comments about technologies that may be useful after site discovery.

Results:

1. Sub-Bottom Profilers

The chirp system was recommended over conventional sub-bottom profilers. Chirp has a digital format that allows more flexible control over data output. It can transmit wide band FM signals in multiple frequencies that produce good quality data. Conventional sub-bottom profilers produce alot of background noise in shallow water, although electronic accessories are available to reduce this noise. Chirp works effectively in shallow water because it can differentiate and reduce background noise. Chirp retains resolution much deeper than conventional bottom-profilers. It can penetrate to 100+ feet. The chirp sensor can be deployed by ROV, but not over ice because the sensor needs to be immersed. Chirp can profile buried soil horizons, and possibly large site features like fire pits.

Datasonics has recently developed a Chirp II system that promotes the following features:

- Lightweight and portable for small boats and small budgets
- Frequency operation from 500 Hz to 23kHz (optional)
- User-friendly Windows graphics interface for multi-tasking and real-time sonar and sensor data processing and display
- Continuous digital storage and display of all seismic data
- Capability to predict bottom material types
- High power output (4 KW each channel)

A major weakness identified by an expert having field experience with chirp is that the system does *not* appear to have compatibility with other electronics needed to post process recorded data. Nor can it adequately incorporate the data into a spacial information system. In addition, the playback of profiles appears to be hardware specific.

2. Ground Penetrating Radar

GPR has better resolution than sub-bottom profilers (including chirp). It is highly reliable and inexpensive to deploy. GPR can be deployed from a small boat and will work in freshwater. The system may work through ice, but there is a lack of studies to make a determination of its effectiveness. Different sensors (antenna arrays) are available for different conditions. GPR should be able to distinguish buried soil horizons, as well as many site features. It works well in identifying charcoal, or features with high mineral content or high conductivity.

3. Side-Scan Sonar and Laser Scanning

Side-scan sonar or laser scanning would be beneficial to deploy in conjunction with a subsurface profiling system. These technologies can detect patterns in submerged lands topography and surface sediments that may indicate a potential for sub-bottom features.

4. Core Samples

Vibra-coring and conventional core sampling should be effective in well-consolidated sediments. Gravity, piston, and boomerang corers can obtain core samples up to 15 meters long in varying conditions of water depth and sediment type. A micro-camera can be inserted into the bore hole for inspection. Soft, unconsolidated sediments will be more difficult. Vacuum bottle systems may work, but it would involve testing and maybe some development.

5. Positioning for ROV Operations

Targets can be set-up underwater to delineate an underwater grid. The targets are then tied into topside GPS coordinates. An ROV can then navigate and be positioned within the grid using an acoustic scanning system.

6. Excavation

Trench box and VAT (vehicle assisted tools) may work well for excavation. Systems include water jetting, multiple cameras, and manipulators. These are fairly user friendly systems that archaeologists without prior experience should be able to operate.

SYSTEM RECOMMENDATIONS

Technology systems recommended for the next phase of the Saginaw Bay Archaeology Project are based on the literature review and expert opinion:

1. Test a GPR deployed from a small boat. Tests should include the use of an ROV outfitted with a camera to gain a better understanding of GPR data from the Saginaw Bay area and its interpretation. If the data are of good quality, then conduct a GPR survey while running also side scan and sector scanning sonar. The sonars would provide clues from topographic features that may be valuable in interpreting sub-bottom stratigraphy.
2. If GPR data are of poor quality or difficult to interpret, the project should conduct sub-bottom profiling with a chirp system.
3. Continue discussions with experts in sub-bottom profiling to better define technical specifications necessary for the project.
4. Assess the cost effectiveness of various underwater technologies and operational alternatives (e.g., quality of data vs. cost, purchase of

technology vs. lease, size of boat, deployment through water or ice). Cost effectiveness should consider whether the *informational* benefits realized from different alternatives justify additional costs.

TECHNOLOGY ASSISTANCE

<u>Corporate Contacts</u>

Benthos
49 Edgerton Drive
North Falmouth, MA 02556-2826
(508) 563-1000

Bottom coring equipment; ROV systems; underwater imaging systems

Datasonics, Inc.
P.O. Box 8
Cataumet, MA 02534
(508) 563-5511

Seafloor imaging systems; chirp sub-bottom profilers

DWS International
802 North Carancahua Street, Suite 750
Corpus Christi, TX 78470
(512) 883-0961

Marine engineering and survey services; sub-bottom profilers

Espey, Huston & Associates, Inc.
P.O. Box 519
Austin, TX 78767-0519
(512) 329-8342

Underwater engineering and environmental consulting (including archaeology)

Hibbard Marine
477 Gray Woods Lane
Lake Angelus, MI 48326
(313) 335-5710

Underwater survey services; GPR systems; ROV systems

Klein Associates
11 Klein Drive
Salem, NH 03079
(603) 893-6131

Side scan sonar systems

Marine Sonic Technology, Ltd.
5508 George Washington Memorial Highway
White Marsh, VA 23183-0730
(804) 693-9602

Side scan sonar systems; SHARPS underwater positioning and ranging

Oceaneering International, Inc.
16001 Park Ten Place, Suite 600
Houston, Texas 77084
(713) 578-8868

Engineering services and hardware for operating in harsh environments, including deep ocean search and survey

Science Applications International Corporation (SAIC)
Maritime Technology Group
10260 Campus Point Drive, MS A3
San Diego, CA 92121
(619) 458-2639

Underwater laser imaging systems

Government Contacts

Minerals Management Service
MMS - MS 4360
381 Elden St.
Herndon, VA 22070
(703) 787-1736

National Center for Preservation Technology and Training (NCPTT)
NSU Box 5682
Natchitoches, LA 71497
(318) 357-6464

National Park Service
Submerged Cultural Resources Unit
Intermountain Cultural Resource Center
P.O. Box 728
Santa Fe, NM 87504
(505) 988-6750

U.S. Army Corps of Engineers
Waterways Experiment Station
3939 Halls Ferry Road
Vicksburg, MS 39180-6199
(800) 522-6937

National Undersea Research Center
University of Connecticut
Avery Point Campus
1084 Shennecossett Road
Groton, CT 06340
(203) 445-4714

REFERENCES CITED

Bolsenga, S.J., G.M. Greene, and K.M. Hinkel.
1988. Nearshore Great Lakes Ice Statistics. NOAA Technical Memorandum ERL GLERL-69. Great Lakes Environmental Research Laboratory, National Oceanic and Atmospheric Administration, Ann Arbor, Michigan.

Curran, Paul J.
1985. Principles of Remote-Sensing. Longman, New York.

Dolan, David M., N. David Warry, Ronald Rossmann, and Trefor B. Reynoldson.
1986. Lake Huron 1980 Intensive Survey Summary Report. International Joint Commission, Windsor, Ontario, Canada.

Heimmer, Don H.
1992. Near-Surface, High Resolution Geophysical Methods for Cultural Resource Management and Archaeological Investigations. Geo-Recovery Systems, Inc., Golden, Colorado.

Mooradian, Greg, Jay Eggert, Ed Saade, and Drew Carey.
1993. High resolution, high search-rate underwater imaging using laser line scanning. Paper presented at IRIS, Naval Postgraduate School, Monterey, CA.

Murphy, Larry, Tim Leary, and Andrew Williamson.
1995. Standardizing seabed classification techniques. Sea Technology 36(7):15-21.

Office of Technology Assessment (OTA).
1986. Technologies for Prehistoric and Historic Preservation. Report OTA-E-319, U.S. Congress. U.S. Government Printing Office, Washington, D.C.

Skytte, Kurt.
1994. Engineering a small system. IEEE Spectrum 3:63-65.